APPENDIX E

Job Requirements and Physical Demands Survey

Scientific Basis for the Job Requirements and Physical Demands Survey

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1.0 OVERVIEW OF THE JOB REQUIREMENTS AND PHYSICAL DEMANDS SURVEY DEVELOPMENT

The purpose of this document is to provide the Survey development criteria, development rationale, and the rationale and results of all testing and validation procedures performed during the Survey development. Section 1.0 is a brief overview of the entire project. Section 2.0 contains detailed information regarding the Survey development, and Section 3.0 contains detailed information regarding the Survey testing and validation procedures. The attachments contain documentation for each question used in the Survey, statistical validation summaries, and raw statistical data.

1.1 Development Criteria

One of the Air Force's primary objectives was to develop a written tool that can be easily administered to work area employees by Public Health technicians. Other specific design criteria, established by the Air Force, are listed in **Table 1.1**.

Table 1.1 Job Requirements and Physical Demands Survey Development Criteria

- The Survey is designed to be administered to an assembled group of work area employees within one hour.
- The Survey is designed to enable a Public Health technician to analyze the data for 25 work area employees within four consecutive hours.
- The Survey provides a means for employees to identify specific work processes, activities, and tasks which they believe are related to their reported musculoskeletal discomfort and/or work-related musculoskeletal disorders (WMDs).
- Results of the Survey will help the base Ergonomics Working Group (EWG) determine if a Potential Ergonomic Problem Area (PEPA) should be classified as an Ergonomic Problem Area (EPRA). An EPRA is a work area where an association can be shown between ergonomic risk factors, employee-reported musculoskeletal discomfort, and employee-reported, medically confirmed WMDs (if applicable).
- Results of the Survey will prioritize EPRA-classified work areas for "task specific" analyses and/or problem-solving efforts.
- Results of the Survey provide an indication of and the relative importance of ergonomic, psychosocial, and individual factors that may be present in the work area.
- Data from the Survey allows calculation of employee-reported discomfort prevalence rates.

In addition, while the primary purpose of the Survey is not to judge the effectiveness of the Air Force injury and illness reporting system, the Survey data from a particular work area should enable the Public Health technician and/or the EWG to determine whether it is likely that employees are under-reporting their musculoskeletal discomfort or symptoms of WMDs.

1.2 Development Process

The Survey design is the result of an iterative development, testing, and validation process that enlisted and benefited from the support and cooperation of Air Force personnel at several Air Force installations:

- Armstrong Laboratory, Brooks AFB, TX;
- Cape Cod AS, MA;
- Malmstrom AFB, MT;
- Patrick AFB, FL; and
- Peterson AFB, CO.

1.2.1 Development of the Initial Survey

The development process began with a review of the scientific literature. The purpose of the review was to identify other screening tools or features of other screening tools that could be used to satisfy the criteria established by the Air Force. The literature review revealed that there is a lack of established and validated employee survey tools for prioritizing ergonomic hazards in the workplace. (For more information see Section 2, pp. 2-1). When possible, individual questions were extracted from surveys or questionnaires reported in peer reviewed journals. Questions were also extracted either from widely used surveys or created by extrapolating from established ergonomic risk factors. This course of actions was taken to maximize the use of existing, albeit limited information.

The process continued with site visits to selected USAF Space Command installations: Cape Cod AS, MA; Malmstrom AFB, MT; and Patrick AFB, FL. The ergonomists video-taped jobs in PEPA and non-PEPA shops. The members elicited input from Public Health offices and Bioenvironmental Engineering Services to ensure familiarity with the type of work being performed in the shops. The purpose of the site visits was to ensure that the final Survey tool reflected the types and varieties of work situations found throughout the Air Force.

The Survey incorporated the results of the literature review and site visits, criteria established by the Air Force, and a series of discussions with Air Force-designated technical advisors. An iterative approach was used in order to incorporate ideas from all Survey contributors. Prior to

conducting the reproducibility testing, seven different versions of the Survey had been developed.

1.2.2 Testing and Validation

The purpose of the testing and validation process was to establish the strengths and limitations of the initial Survey and to identify the need for changes based on quantitative information. The testing and validation process was conducted in three distinct phases: usability testing, reproducibility testing, and validity testing. An overview is provided below. (For a detailed discussion of the testing and validation process and results, refer to Section 3).

Usability testing was performed to ensure Public Health technicians would be able to use the Survey as intended, that the Survey met the design criteria, and that the questions were understandable. The testing was conducted at Malmstrom AFB and focused on the Survey administration process (e.g., adherence to completion time criteria), the Survey questions (e.g., understandable, applicable, etc.), and the scoring procedures (e.g., adherence to completion time criteria, ease of use, etc.). Input from the test group at Malmstrom AFB resulted in significant improvements to ease the use and efficiency of the Survey administration and scoring process.

Reproducibility testing was performed to determine how consistently the Survey yielded the same results. In other words, the testing was done to see if employees responded the same way to a question when the Survey was administered at two different times. Test/re-test reproducibility was examined for the Survey since it is a self-reporting (employee) tool. A two-week test/re-test evaluation was conducted at Peterson AFB. This time period was selected to ensure sufficient delay so that participants would not remember their responses while maintaining a short enough interval that the participant's job demands and discomfort would remain constant.

Validity testing was conducted to measure how closely the results (e.g., Ergonomic Priority Ranking for several work areas) from an experienced ergonomist matched those which were generated from administering the Survey. The similarity of rankings determined how closely the two measures agreed with each other. An experienced Ergonomist visited 31 work areas prior to administration of the Survey: five at Cape Cod AS and 28 at Patrick AFB. Several measures were taken to prevent the Ergonomist from biasing the Survey responses. This included the requirement that the Survey could not be administered to a work area visited by the Ergonomist until two weeks had passed. The two-week time period was established to minimize the potential that employees would respond to a Survey question based on discussions that may have occurred during the Ergonomist's shop visits while again maintaining a short enough interval that the participants job demands and discomfort would remain constant. The Survey was administered by base personnel from Patrick AFB and Peterson AFB (in cooperation with Cape Cod AS). Results from the validity testing revealed that there was a statistically significant correlation between the overall work area Ergonomic Priority Rankings provided by the Ergonomist and those which resulted from administration of the Survey. This means that, overall, the Survey results would be expected to agree with the findings of an experienced ergonomist.

2.0 PRACTICAL BASIS FOR THE SURVEY METHODOLOGY

This section of the research report contains detailed information related to the development of the Survey, including the Survey criteria and the rationale and reasoning used to select, modify, and/or develop each question.

2.1 Literature Review

The initial step in the Survey development process was to perform a literature review in order to determine if a survey screening tool was the most appropriate method to use to obtain both ergonomic risk factor and health surveillance data. Another purpose of the literature review was to identify other screening tools or features of other screening tools that could be used to satisfy the criteria established by the Air Force. The literature review revealed a wide range of job-focused risk assessments requiring levels of ergonomic knowledge varying from none to those possessed by an experienced ergonomist (Cole, 1995 [1]; Keyserling et al, 1993 [2]; Reynolds, Drury & Broderick, 1994 [3]). Most of the established methods require at least several days of training to complete properly. Several job specific screening methods have been developed and used to "survey" employees with little or no ergonomic training ([1], [3]). Surveys designed for collecting epidemiological data from employees have also been developed (Wiktorian et al, 1991 [4]).

There is one fundamental difference between an epidemiological survey and a screening survey. An epidemiology survey identifies activities that have historically been associated with WMDs but does not provide directive information about future intervention. A screening survey is generally used to target or prioritize jobs for intervention.

The primary factors which were considered when selecting and designing the appropriate screening methodology are:

1. What level of expertise is required?

2. What are the time requirements?

3. What are the associated costs?

4. How invasive is the methodology?

5. How valid are the scores obtained?

Assessment methods currently in use were reviewed by The Joyce Institute/A Unit of Arthur D. Little, Inc. ergonomists to identify advantages or features which could be incorporated into the Survey design. Table 2.1 summarizes the advantages and disadvantages of the various assessment approaches based on results of the ergonomists' review.

Table 2.1 Advantages and Disadvantages of Ergonomic Assessment Approaches

Assessment Type	Method	Advantages	Disadvantages
Passive surveillance (screening) for WMDs	Records Review - OSHA 200 log, medical reports, nurses logs, workers' compensation reports, insurance reports.	• Process can be quick and inexpensive if data is readily available. • Possible to prioritize action according to frequency, severity, and/or cost of cases.	Conclusions made from the data are typically limited to identifying departments or work areas - not tasks in which problems may exist. Approach is totally reactive - judgments are made based only on reported injuries. Other factors may influence injury reporting (e.g., downsizing) and cost (e.g., case management).
Active surveillance for WMDs	Physician- or Health Care Provider-sponsored health assessments	• Provides detailed baseline information on individual and group employee health. Qualified health care personnel perform evaluations (e.g. Phalens test, Tinels Sign, etc.) to identify symptoms or conditions that may indicate the presence or onset of WMDs. • Information on individual factors (e.g., previous injuries) can be obtained.	Assessment process is expensive and time-intensive. Does not indicate potential source of symptoms or contributing job factors.

Table 2.1 Advantages and Disadvantages of Ergonomic Assessment Methods (Contd.)

Assessment Type	Method	Advantages	Disadvantages
Active surveillance for risk factors	Questionnaires - surveys or interviews	• Questionnaires are quick and inexpensive to administer and are non-invasive. Few technical skills are required for survey administration. They can also provide some indication of potential sources (jobs, tasks, etc.) of employee-reported discomfort.	Provides only general information on exposure to ergonomic risk factors. Due to the subjective nature of the data collection process, results may have lower validity than those from other methods.
Active surveillance for risk factors (cont.)	Observational Techniques- checklists, task analyses	• Process requires only moderate time and cost to perform and has a low level of invasiveness. • Techniques can provide detailed information on risk factor exposure, and identification of root causes and potential control options. • Analysis results may be used to prioritize action on specific tasks.	Moderate level of technical skill is required. Results provide moderate detail and validity. Conclusions on priority for change are based on the training and observational skills of the technician.
Active surveillance for risk factors (cont.)	Direct Measurements- EMG, electronic sensors, goniometers	• Provides higher level of detail and precision. Data can be used to assess potential risk of exposure when standards are available (e.g., vibration exposure). Methods provide standardized means	Process is often costly, time intensive, and requires a high level of technical skill to perform accurate measurements. Direct measurement can be highly invasive. Costs of obtaining data may outweigh the value as a problem-solving tool due to the lack of availability of validated exposure data

Assessment Type	Method	Advantages	Disadvantages
		for measuring reduction in exposure after improvements are made.	(e.g., grip force).

The literature review indicated that a questionnaire/survey approach was the most appropriate method for obtaining both risk factor and health surveillance data.

2.2 Survey Design

The Survey was designed to accomplish the following specific objectives listed below:

- The Survey can be administered to an assembled group of work area employees within one hour.

- The Survey design enables the Public Health technician to analyze the data for 25 work area employees within four consecutive hours.

- The Survey provides a means for employees to identify specific work processes, activities, and tasks which they believe are related to their reported musculoskeletal discomfort and/or WMD.

- Results of the Survey will help the base EWG members determine if a PEPA should be classified as an EPRA.

- Results of the Survey will be used to prioritize EPRA-classified work areas for "task specific" analyses and/or problem-solving efforts.

- Results of the Survey provide an indication of and the relative importance of ergonomic, psychosocial, and individual factors which may be present in the work area.

- Data from the Survey allows calculation of employee-reported discomfort prevalence rates.

The above objectives are consistent with the requirement to provide a quick and effective screening tool which prioritizes shops, identifies the potential source(s) of exposure to ergonomic risk factors, and suggests strategies for follow-up.

Another primary design objective was to develop one survey which would be applicable to each of four work area types found throughout the Air Force. The work areas are:

- Maintenance/Inspection;

- Assembly Line;
- Warehouse; and
- Administrative.

The Survey also had to obtain data which related to both the employee's physical experience (e.g., comfort, discomfort, etc.) with the job, as well as the overall exposure to ergonomic risk factors. Priorities were to be established based on both types of information. In addition, since the results were also intended to be used to identify opportunities for problem solving, the Survey was designed to identify common tasks (e.g. what do the employees do on a routine basis) as well as tasks or activities that employees believe may be a source of concern. As a result, the Survey is comprised of four sections:

- Part I: Description of Work
- Part II: Your Body's Response to Work Demands
- Part III: Work Content
- Part IV: Process Improvement Opportunities.

2.2.1 Cover Page

The cover page enables employees to identify the workplace (shop) and location of work as well as to specify selected employment-related demographics.

Information collected on the cover page (**Figure 2.1**) is expected to be used only for record keeping. Specifically, the information **will not** be used to identify individuals within any of the shops. Data requested on demographics (e.g., gender, work group, age category, length of service, etc.) may be used by the Air Force in post hoc, installation-wide analyses.

Figure 2.1 Cover Page

<table>
<tr><td>Job Requirements and Physical Demands Survey</td><td>Date (YYMMDD)</td><td>Workplace Identifier:</td><td colspan="2"></td></tr>
<tr><td colspan="2" rowspan="4">(use this space for mechanical imprint)</td><td colspan="2">Base</td><td>Organization</td></tr>
<tr><td colspan="3">Workplace</td></tr>
<tr><td colspan="2">Bldg. No/Location</td><td>Room/Area</td></tr>
<tr><td colspan="3">AFSC/Job Series</td></tr>
<tr><td colspan="5">Gender: Female ❍ Male ❍</td></tr>
<tr><td colspan="5">Work Group: Civilian ❍ Grade:_____ Military ❍ Rank:_____</td></tr>
<tr><td colspan="5">Age Category: 20 and under ❍ 21-30 ❍ 31-40 ❍ over 40 ❍</td></tr>
<tr><td colspan="5">Length of service at this base: less than one year ❍ more than one year ❍</td></tr>
<tr><td colspan="5">Length of time in current shop: less than one year ❍ more than one year ❍</td></tr>
<tr><td colspan="5">Have you completed this questionnaire before? Yes ❍ No ❍</td></tr>
</table>

2.2.2 Part I: Description of Work

Part I is divided into three sections: Job Factors, Organizational Factors, and Physical Effort.

2.2.2.1 Job Factors

The Job Factors section will provide Public Health information on the extent employees may be exposed to ergonomic risk factors that may contribute to WMDs. The following paragraphs describe the research findings associated with developing this portion of the Survey, as well as the purpose of the questions, the rationale for the responses, and what the results indicate. An excerpt from the Job Factors section is included as **Figure 2.2**.

2.2.2.1.1 Research Findings

The section examines the prevalence of exposure to ergonomic risk factors within a shop. The categories for duration of exposure (never, less than 2 hours, 2 to 4 hours, 4 to 8 hours) were established based on the OSHA draft standard. Ergonomic risk factors to which employees were exposed an average of less than 2 hours per day have a lower priority than more prevalent factors. The selection of individual questions for inclusion in the risk factor section of the Survey was based on the steps listed below.

1. Review of literature for existing questions.
2. Review of literature for established risk factors.
3. Selection of questions and risk factors represented in Air Force tasks.
4. Formulation of first-person statements based on existing questions and established risk factors.
5. Usability testing conducted at Malmstrom AFB.
6. Revisions to question wording and selection based on user feedback.
7. Reproducibility testing at Peterson AFB.
8. Revision based on results of reproducibility testing.

A review of the literature indicated that there is a lack of established and validated employee survey tools for prioritizing ergonomic hazards in the work place. The lack of validated ergonomic surveys has been noted by other researchers (Buckle, 1995 [5]; Burdorf, 1992 [6]; Kilbom, 1994 [7]; Wiktorian et al, 1993 [4]; Baron et al, 1996 [8]). The lack of validated assessment surveys is not limited to the field of ergonomics; it has also been noted in work history (Bond et al, 1988 [9]) and physical activity measures (Washburn and Montoye, 1986 [10]).

Figure 2.2 Job Factors

A. DESCRIPTION OF WORK

SHOULDER / NECK

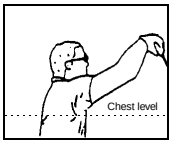


Figure A.

	Never	0-2 hrs.	2-4 hrs.	4-8 hrs.
1. I work with my hands at or above chest level. ***(Figure A.)***	❍	❍	❍	❍
2. To get to or to do my work, I must lay on my back or side and work with my arms up.	❍	❍	❍	❍
3. I must hold or carry materials (or large stacks of files) during the course of my work.	❍	❍	❍	❍
4. I force or yank components or work objects in order to complete a task.	❍	❍	❍	❍
5. I reach or hold my arms in front of or behind my body (e.g., using a keyboard, filing, handling parts, performing inspection tasks, pushing or pulling carts, etc.). ***(Figures B.)***	❍	❍	❍	❍

Figure B.

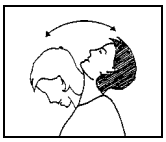


Figure C.

6. My neck is tipped forward or backward when I work. (***Figure C.)***	❍	❍	❍	❍

Figure D.

7. I cradle a phone or other device between my neck and shoulder. ***(Figure D.)***	❍	❍	❍	❍

The only two employee survey tools identified in the literature which have undergone any reproducibility research (Cole & Rosa, 1994 [11]; [8]) focus on epidemiological descriptions of work place stressors or activities without prioritizing or classifying the resulting risks. Other survey tools have been reported in the literature without accompanying validation research. The reproducibility and/or validity of several observational analysis questionnaires has been reported (Kemmlert, 1994 [12]; Lifshitz & Armstrong, 1986 [13]; McAtamney & Corlett, 1993 [14]).

Where possible, questions were extracted from survey or questionnaire tools reported in peer reviewed journals. In other cases, the questions were extracted from either widely used surveys (Steelcase, undated [15]) or extrapolated from established risk factors (e.g., stressful postures, excessive force, etc.). Questions were selected and modified to describe risk factors in terms associated with the tasks which employees perform [7]. A complete list of risk factor questions and the research literature supporting their inclusion as Job Factor Questions is presented in Attachment 1 of this Appendix. Each of the questions was altered slightly such that it would be read in first person. Responses to all questions were altered to correspond to the time categories selected. Since the original risk factor verbiage was essentially retained, these slight alterations are not expected to impact past reported reproducibility and/or validity. Several questions were altered more significantly. For example, question 1, "I work with my hands at or above chest level." was modified from the original "Is an elbow used at or above mid-torso level?" to achieve a more direct expression of the risk factor. Since "chest level" is easier to identify by the non-specialist than "mid-torso level", the change was expected to maintain if not improve question reproducibility (i.e., remove the need for user interpretation). The risk factor basis for the question is retained. Therefore, while some of the alterations may appear substantial, the changes are not expected to reduce past reported reproducibility and/or validity. A pilot investigation of test/retest reproducibility was performed on these revised questions to verify that reproducibility remained consistent or improved.

2.2.2.1.2 Questions (Q1-Q38)

In the Job Factors section, the employee is asked to respond to a series of questions which relate to the variety of physical demands in work activities. The questions have been grouped into five "body zones": shoulder/neck (Q1-Q7), hand/wrist/arm (Q8-Q21), back/torso (Q22-Q30), legs/feet (Q31-33), and head/eyes (Q35-Q38). The questions are representative of the types of ergonomic risk factors that are most likely to be found in Air Force work situations.

The specific questions that are included were designed to ensure that each general risk factor type discussed in the scientific literature (e.g., posture, force, repetition, etc.) were reflected. The questions were also designed such that they would be applicable to each of the four work area types found throughout the Air Force: Administrative, Assembly, Maintenance/Inspection, and Warehouse.

Each section has a different number of questions. For example, there are 14 questions for hand/wrist/arm and four questions for legs/feet. The number of questions in each section generally reflects the present state of ergonomic research and knowledge about risk factors. In other words, hand/wrist/arm ergonomic research has provided greater insight into the potential causes of hand/wrist/arm WMDs than research which has been conducted for the legs/feet.

2.2.2.1.3 Responses

For each question, the employee estimates the approximate amount of time that their work exposes them to that job factor (e.g., I work with my hands at or above chest level). The choices are: 0-2 hours, 2-4 hours, 4-8 hours, or never/NA. The first three response choices were selected to remain consistent, in concept with the 1995 OSHA Draft Ergonomics Standard [16] and the response categories proposed in the American National Standards Institute (ANSI) National Safety Council Draft Standard Z-365 (ANSI Z-365) (ANSI, 1995 [17]). "Never" was added in response to feedback obtained during the alpha and beta testing phases of the development process. For example, employees who were never exposed to a particular Job Factor commented that responding in the "0-2 hours" category seemed like an overstatement. Furthermore, employees who worked or were exposed to a Job Factor for 1-1/2 hours commented that since they were being grouped with employees who were exposed for "0" hours, their own exposure was discounted.

2.2.2.1.4 What the Section Indicates

Responses averaged across the shop indicate the extent to which employees may be exposed to ergonomic risk factors that may contribute to WMDs. In addition grouping the questions by body zones also helps identify the body zone(s) which may be exposed to the greatest extent and allows for comparison to responses in the discomfort section, which are also grouped by body zone. This will help Public Health and the EWG establish targets for effective problem solving strategies for shops that are upgraded to EPRA status.

The "Risk Factor Rating" for each body zone is used in the Survey Priority Rank calculation for the shop.

2.2.2.2 Organizational Factors

The following paragraphs describe the research findings associated with developing this portion of the Survey, as well as the purpose of the questions, the rationale for the responses, and what the results indicate. The Organizational Factors section is included as **Figure 2.3**.

Figure 2.3 Organizational Factors

B. ORGANIZATIONAL FACTORS

	Strongly Disagree	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*
	1	**2**	**3**	**4**	**5**
39. I often feel unclear on what the scope and responsibilities of my job are.	❍	❍	❍	❍	❍
40. I often feel that I have too heavy of a workload, one that I could not possibly finish during an ordinary workday.	❍	❍	❍	❍	❍
41. I often feel that I will not be able to satisfy the conflicting demands of various people around me.	❍	❍	❍	❍	❍
42. I often find myself unable to get information needed to carry out my job.	❍	❍	❍	❍	❍
43. I often do not know what my supervisor thinks of me, how he/she evaluates my performance.	❍	❍	❍	❍	❍
44. I often think that the amount of work I have to do may interfere with how well it's done.	❍	❍	❍	❍	❍

2.2.2.2.1 Research Findings

Questions related to job stress (overload, role ambiguity, recognition, job suitability) are included in the survey to reflect the fact that the employee is part of an environment which creates both physical and organizational demands. These issues can be important to the Air Force since studies have shown that organizations that ignore these issues may experience decreases in productivity, as well as increases in injuries/illnesses, Workers' Compensation claims, and absenteeism. In one study (Bigos et al, 1991 [18]), which involved 3,020 workers over a four year period, 279 back injuries were reported. Other than prior injuries, organizational factors were the most significant predictors of claims. The researchers concluded that report of (back) injury is an event that may be influenced by a complex set of factors that cannot be understood solely in physical ergonomic terms. Each of the questions included in the Survey were taken directly from a study on organizational stress and its impact on absenteeism (Khan et al, 1964 [19]). The questions were used with only minor modifications (to fit the Survey language) since they already expressed the organizational issues in an unemotional/balanced way. A five-point strongly disagree or strongly agree scale was chosen for the responses because it is a familiar format and because five-point scales appear to provide the greatest utility (Meister, 1985). *(Since the questions were all taken from the same research source, a question-by-question discussion,*

which was presented in the Job Factors section [taken from many research sources], is not necessary.)

As a result, questions related to job stress (overload, role ambiguity, recognition, job suitability) have been added to the Survey to reflect the fact that the employee is part of an environment which creates both physical and organizational demands.

2.2.2.2.2 Questions (Q39-Q44)

There are six questions that deal with organizational issues. Organizational Factors are included in the Survey to provide Public Health with insight into how employees' well-being (e.g., reports of discomfort) may be related to how they perceive their worth to the organization.

2.2.2.2.3 Responses

The employee is asked to respond to each question using a five-point scale: strongly disagree, disagree, neutral, agree, and strongly disagree.

2.2.2.2.4 What the Section Indicates

Responses averaged across the shop indicate the possible extent to which Organizational Factors may be influencing the employees' attitude towards their work. For example, if the Organizational Factor results for the entire shop indicate that the majority of the employees understand their responsibilities, feel that the work load is reasonable, feel that they are able to satisfy the demands of others, are able to get the information that they need to carry out their jobs, and so on, Public Health may feel confident about the results generated from the Job Factors section. In other words, Public Health would not need to be concerned (as they might be if the entire shop reported the presence of negative Organizational Factors - e.g., the employees think that the amount of work they have interferes with how well the work is done) that employees reported a higher level of Job Factors than are actually present in the work.

The Organizational Rating is based on responses to this section and is not used in the Survey Priority Rank calculation. The organizational ratings are not directly incorporated into the Survey Priority Rank calculation in order to retain a job factor to discomfort factor link in determining the ranks. Maintaining these ratings as a separate item allows EWG to make the decision regarding EPRA status based on the likelihood that organizational factors are contributing to discomfort without the presence of intervening risk factors.

2.2.2.3 Physical Effort

The following paragraphs describe the research findings associated with developing this portion of the Survey, as well as the purpose of the questions, the rationale for the responses, and what the results indicate. The Physical Effort section is included as **Figure 2.4**.

Figure 2.4 Physical Effort

C. PHYSICAL EFFORT

45. How would you describe the physical effort required of your job?

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No exertion at all	Extremely light		Very light		Light		Somewhat hard		Hard		Very hard		Extremely hard	Maximal exertion
❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍

2.2.2.3.1 Research Findings

The scale used in the Survey is a version of the Borg Scale (Borg, 1970 [20]). The specific terms were adopted based on a modified Borg scale, which has been shown to be effective in obtaining ratings of perceived exertion. Because this scale was taken directly from a validated, widely used source, detailed re-validation of this question was not performed.

2.2.2.3.2 Question (Q45)

Question 45 asks the employee to classify the overall physical effort required by tasks that are performed an approximately daily basis. This question provides a good indication of employees' perception of work load/work demands throughout the shop.

2.2.2.3.3 Responses

There are 15 response choices, from 6 - no exertion at all, to 20 - maximal exertion.

2.2.2.3.4 What the Section Indicates

The shop result from this section provides an indication of how "easy" or "hard" the employees think the work is. The Air Force may use this information in post hoc analyses to determine how employee perception of work effort corresponds to reported injuries or illnesses. The Physical Effort Score for the shop, based on responses to question 45 is not used in the Priority Rank calculation. The physical effort is not used directly in the Priority Rank calculations because the amount of physical effort can be misleading relative to WMDs. A highly repetitive hand and finger task may require little overall physical effort because the forces exerted are low and the body mass moved is small, while contributing to WMDs. Alternatively, a task may require a large variety of moderately forceful whole body movements. Because of the task variety and the nature of the tasks, the risk for WMD may be minimal while the effort required is high.

2.2.3 Part II: Your Body's Response to Work Demands

This section enables the employee to identify the occurrence, location, frequency, and/or degree of discomfort that may be associated with daily work activities.

Part II is divided into two sections: Discomfort Factors and General Questions.

2.2.3.1 Discomfort Factors

The following paragraphs describe the research findings associated with developing this portion of the Survey, as well as the purpose of the questions, the rationale for the responses, and what the results indicate. The Discomfort Factors section is included as **Figure 2.5**.

2.2.3.1.1 Research Findings The Discomfort Factors section was based on lessons learned from available symptom survey tools and the literature. The final form of the section was also shaped by feedback from survey test participants and the Air Force.

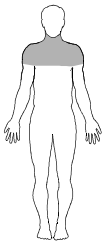
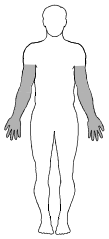
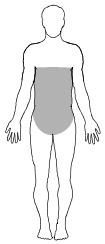
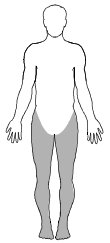
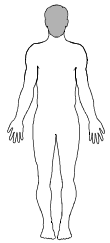
The symptom survey included in the (draft) ANSI Z-365 Standard for the Control of Cumulative Trauma Disorders [17] provided a layout and format concept for the Discomfort Factors section. This format was selected because it is logical to ask questions by body zone. The format, which was improved by adding illustrations, allows the survey participant to quickly identify the body zone presented. The concept of shading the intended body zone within a whole body illustration was derived from Kuorinka et al, 1987 [21].

One of the major decisions for the Discomfort Factors section was to include questions on both the severity and frequency of a particular physical complaint. Many of the surveys found in the literature considered only severity or frequency, not both. Both the ANSI Z-365 [17] and the Johnson and Johnson (Johnson and Johnson, 1995 [22]) surveys address both frequency and severity issues.

Figure 2.5 Discomfort Factors

D. DISCOMFORT FACTORS

This section enables you to identify how your body responds to the demands of ***your job***. In each section, answer the first question. If the answer is "no" go to the next column.

Question	 **Shoulder/Neck**	 **Hands/Wrists/Arms**	 **Back/Torso**	 **Legs/Feet**	 **Head/Eyes**
• In the past 12 months, have you experienced <u>any</u> discomfort, fatigue, numbness, or pain that ***relates to your job***?	46. Yes ❍ No ❍ ***If "no", go to question 49***	49. Yes ❍ No ❍ ***If "no", go to question 52***	52. Yes ❍ No ❍ ***If "no", go to question 55***	55. Yes ❍ No ❍ ***If "no", go to question 58***	58. Yes ❍ No ❍ ***If "no", go to question 61***
• How often do you experience discomfort, fatigue, numbness, or pain in this region of the body?	47. Daily ❍ Weekly ❍ Monthly ❍	50. Daily ❍ Weekly ❍ Monthly ❍	53. Daily ❍ Weekly ❍ Monthly ❍	56. Daily ❍ Weekly ❍ Monthly ❍	59. Daily ❍ Weekly ❍ Monthly ❍
• On average, how severe is the discomfort, fatigue, numbness, or pain in this region of the body?	48. Mild ❍ Moderate ❍ Severe ❍	51. Mild ❍ Moderate ❍ Severe ❍	54. Mild ❍ Moderate ❍ Severe ❍	57. Mild ❍ Moderate ❍ Severe ❍	60. Mild ❍ Moderate ❍ Severe ❍

Other questions included in many of the surveys found in the literature were either variations of a frequency or severity question or questions which would not provide information useful to the Air Force. Therefore these questions were not further considered for incorporation into the Survey.

The severity scale, "Mild, Moderate, Severe," was derived from the Johnson and Johnson symptom survey. This scale was used because it is a three-point scale and the terminology is easy to understand.

The frequency scale, "Daily, Weekly, Monthly," was derived from Marley and Kumar (1996 [23]). Marley and Kumar used "Constantly (nearly every day), Frequently (a few times/week), and Rarely (a few times/month)." Again, the three-point scale was selected for its simplicity. The terminology was simplified to make it easier to understand.

The ANSI Z.365 symptom survey provided the basis for Q46-Q60. In addition, the work of Dickinson et al (1992 [24]) provided helpful guidance in the development of these questions. These questions were also modified to reflect feedback obtained during Survey testing. One change made in response to feedback was to eliminate the need for the employee to answer questions that were not relevant to his/her experience. To enable the user to complete the section as quickly as possible, a question was added (Questions 46, 49, 52, 55, and 58) prior to the frequency and severity questions for each body zone. The question asked if the employee had experienced <u>any</u> discomfort, pain, etc. If the answer was no, the employee is directed to skip the "frequency" and "severity" questions for that particular body zone since those questions would not be relevant. Another significant change was to divide the questions into two sections: Discomfort Factors and General Questions. Discomfort Factors were limited only to the frequency and/or severity of pain, discomfort, etc. The separation was made to increase the speed of the scoring process: the Discomfort Factors are used in determining the Discomfort Rating while the General Questions may be used to interpret the Discomfort Rating.

2.2.3.1.2 Questions (Q46-Q60) In Section D, the employee is asked to respond to questions that relate to the occurrence, frequency, and severity of discomfort, fatigue, numbness, or pain in each of the five body zones. The introduction at the top of page 7, "This section enables you to identify how your body responds to the demands of your job," is included to focus the employee's responses to job-related occurrence of any symptoms. (In section E of the Survey, information is obtained that may help identify other potential sources of symptoms.)

The employee symptoms survey included in the proposed ANSI Z.365 standard [17] was used as the basis for the design of the Discomfort Factors section. A picture of the relevant body zone is provided along with the questions to ensure that the employee is able to pinpoint the location of any discomfort, pain, etc., on his/her body, then communicate that information in a consistent way using questions 46-60. Body zones were used instead of body parts (e.g., hand, thigh, etc.) or joints (e.g., knee, elbow) to eliminate the requirement of having employees determine the precise location of their symptoms The concept of using shading to help employees identify the body zones was adopted based on work of Kourinka et al (1987) [21]. Both concepts were used to minimize employee response time.

2.2.3.1.3 Responses The employee is directed to answer questions "by body zone." A response of "no" to the first question directs the employee to proceed to the next column. If the employee responds "yes" to the first question, he/she is then asked to describe the "frequency" and "severity" of the symptoms.

The Criteria Table used to score the Discomfort Factors section is based on the work of Marley and Kumar [23]. These researchers conducted tests to determine the relationship between a person's score on a discomfort assessment tool and his/her likelihood to seek treatment. The research produced a Criteria Table based on discriminant analysis, which categorizes the likelihood of seeking treatment based on severity and frequency scores. The current Criteria Table was developed by modifying the severity scale to a three-point scale. Further adjustment of the Criteria Table was also made to increase specificity (e.g., make it more likely to identify personnel who would choose to seek treatment for their complaints).

The Discomfort (Factors) Rating scale, Low: < or = 30%, Medium: 31-60%, and High: > or = 61%, is also based on the analysis conducted by Marley and Kumar [23]. The analysis indicated that, of the people who sought medical treatment, 64.7% scored in the "very likely to seek treatment" category. Of the people who did not seek medical treatment, 33.4% scored in the "very likely to seek treatment" category. This data was adapted to identify the Discomfort Rating decision points.

2.2.3.1.4 What the Section Indicates Results from this section indicate the common experience with discomfort and/or other physical symptoms for employees as a group. Since the data is interpreted for the group as a whole, there should be little cause for concern about the validity or influence of individual employee reports.

Just as was done for the Job Factors section, grouping the Discomfort Factors by body zones also helps identify the body zone(s) in which employees may be experiencing possible symptoms of WMDs to the greatest extent. Again, this will help Public Health and the EWG establish targets for effective problem solving strategies for shops which are upgraded to EPRA status

The Discomfort Rating that is determined for each body zone is used together with the Risk Factor Rating to determine the overall Priority Rank for the shop.

2.2.3.2 General Questions

The following paragraphs describe the purpose of the questions, the rationale for the responses, and what the results obtained from this portion of the Survey indicate. The General Questions section is included as **Figure 2.6**.

Figure 2.6 General Questions

E. GENERAL QUESTIONS

61. In the past 12 months, have you seen a health care provider for any pain or discomfort that you think **relates to your job**? Yes O No O

62. Do you experience any work-related pain or discomfort that does not improve when you are away from work overnite or over the weekend? Yes O No O

63. In the past 12 months, has any work-related pain or discomfort caused you difficulty in carrying out normal activities (e.g., job, hobby, leisure, etc.)? Yes O No O

64. Has a health care provider ever told you that you have any of the following conditions which you think might be **related to your work**? Yes O No O

- Tendonitis/Tenosynovitis
- Epicondylitis (Tennis Elbow)
- Thoracic Outlet Syndrome
- Ganglion Cyst
- Bursitis
- Back Strain
- Trigger Finger
- Carpal Tunnel Syndrome
- Knee or Ankle Strain
- Overuse Syndrome

65. Do you have or have you ever had one or more of the following conditions? Yes O No O

- Wrist Fracture
- Thyroid Disorder
- Rheumatoid Arthritis
- Hypertension
- Diabetes
- Kidney Disorders
- Gout

2.2.3.2.1 Questions (Q61-65) The questions in this section were developed as a result of several discussions with the Air Force. The purpose of the questions is to enable employees to provide background information (e.g., impact of non-work-related activities, other physical conditions that may be the source of the discomfort, etc.) on reported discomfort, fatigue, etc. Again, since only the results from the shop as a whole will be interpreted, the questions are not to be used to make conclusions about an individual employee or case.

2.2.3.2.2 Responses The format of the questions was chosen to enable employees to respond with a "yes" or "no" answer.

2.2.3.2.3 What the Section Indicates Responses to these questions are not factored into the Priority Rank calculation. They are important, however, in that they offer a means for Public Health to interpret potentially wide discrepancies between the Risk Factor Rating and the Discomfort Rating for a shop. For example,

- the high Priority Rating for the shop (based on high Risk Factor and Discomfort Ratings) and the lack of illness/injury cases reported for the shop may indicate that employees are under-reporting symptoms of WMD;

- pre-existing conditions or injuries (whether they are work-related or otherwise) may be responsible for a high Discomfort Rating for the shop; and

- work-related discomfort or pain has made it difficult for employees who work in this shop to carry out their normal activities.

2.2.4 Part III: Work Content

This section enables employees to provide a basic description of work performed in the shop

The following paragraphs describe the purpose of the questions, the rationale for the responses, and what the results obtained from this portion of the survey indicate. An excerpt from the Work Content section is included as **Figure 2.7**.

Figure 2.7 Work Content

The section below will enable you to describe the content of the work that you do in your current shop.

Fill in the box that describes how frequently you do the task listed, based on the following definitions:

- **Routine:** Performed on three or more days per week.
- **Non-routine:** Performed two days a week or less.
- **Seasonal:** Performed only during certain times of the year.
- **Never/NA:** You do not perform this type of work.

	Type of Work	Work Frequency (Check one)			
		Routine	**Non-Routine**	**Seasonal**	**Never/NA**
66.	abrading	❍	❍	❍	❍
67.	baking	❍	❍	❍	❍
68.	bolting/screwing	❍	❍	❍	❍
69.	calling (telephone use)	❍	❍	❍	❍
70.	chipping	❍	❍	❍	❍

2.2.4.1 Questions

The types of work listed (Q66-Q120) were taken from the Revised Handbook for Analyzing Jobs. In some cases, the task/title has been modified for clarity (e.g., for Q69 - calling, "telephone use" was added to the task title) or grouped according to similar expected risk factor exposure (e.g., for Q86, the task titles for grinding, buffing, and polishing were combined). Blank lines for Q121 and Q122 are provided to enable employees to "write in" task types that were not included on the list.

2.2.4.2 Responses

Four response choices are provided: routine, non-routine, seasonal, and never/NA. The following definitions were adopted:

- Routine tasks: performed three or more days per week.

- Non-routine tasks: performed two days a week or less.

- Seasonal tasks: performed only during certain times of the year.

Routine was originally defined as "performed on an approximately daily basis" by OSHA [16]. The Air Force removed the need for the user to interpret "approximately daily" by suggesting the final definition, "performed three or more times per week." The definitions for non-routine and seasonal were also provided by the Air Force to reflect the wide variety of work duration's found at Air Force installations. During initial testing, Survey participants expressed the need for a response choice to each task type. The never/NA response choice was added based upon this participant input. This was a way of ensuring that the employee considered every task on the list when communicating work content.

2.2.4.3 What the Section Indicates

The Section serves two purposes. The first purpose, as stated above, is to provide Public Health and the EWG some direction on which tasks **could** become the focus of further investigation or problem-solving for EPRA-designated shops. Employees may perform 10-15 different tasks on a routine basis. Responses in this section, however, provide no insight into whether or not employees believe that the tasks may be the source of exposure to ergonomic hazards. The second purpose is to prepare the employees to respond to Part IV. In short, Part III describes which tasks the employees do. Part IV describes which tasks the employees think may be good targets for improvement.

2.2.5 Part IV: Process Improvement Opportunities

This section enables employees to describe the activities that he/she believes place the greatest demands on the body. Responses may be used by Public Health and the EWG to prioritize problem-solving activities within a shop.

The following paragraphs describe the purpose of the questions, the rationale for the responses, and what the results obtained from this portion of the Survey indicate.

2.2.5.1 Questions (1-4)

Four questions are presented to elicit the maximum number of responses from employees with a variety of attitudes toward work. For example, some employees may believe that it is a poor reflection on their own physical condition to admit that their work or part of their work makes them sore. Other employees wait for any opportunity to complain about every ache or pain they experience, whether it is work-related or not. Since these points of view exist and since the purpose of the section is to provide Public Health and the EWG with information on improvement opportunities, the questions are worded to elicit the maximum number of responses.

2.2.5.2 Responses

The employee is asked to write the response in the space provided. Previous trials of the Survey indicate that many employees will offer constructive suggestions for addressing "problem" jobs or tasks in the work area. In most cases, employees will not write a response to all of the questions.

2.2.5.3 What the Section Indicates

A large number of responses to the questions in this section makes the task of establishing problem-solving priorities much easier. For example, Public Health may:

- observe (or obtain a description of) the task;
- review the Survey results to see if the demands of the task are consistent with the Job Factor and Discomfort Ratings reported for the shop;
- if the task demands and Ratings are consistent, the task may be a source for employee exposure to ergonomic risk factors; and/or
- recommend that the task be selected for further investigation or immediate problem-solving.

Public Health summarizes the task list as part of the report to communicate shop needs to Bioenvironmental Engineering Services.

2.3 Risk Rating and Prioritization

The following sections describe the development of the Survey scoring procedures, including the research findings and scoring process design. Individual sections are devoted towards describing the scoring procedures for each section of the Survey.

2.3.1 Research Findings and Scoring Process Overview

As previously stated, validated methods for obtaining risk ratings and priorities from risk factor survey tools are lacking in the scientific literature. Some information is available regarding the likelihood of seeking medical treatment based on the frequency and severity of discomfort [23].

The rationale for determining concerns related to discomfort and scoring for the Survey is based on the methods used by Marley and Kumar [23]. While concerns are identified on an individual basis and indicated by single tally marks on the scoring forms, the risk statement is based on the percent of people indicating concerns. Several key concerns in the selection and development of all scoring methods were the speed and ease of use. This method of determining a risk statement or "rating" satisfies the Air Force's desire to place priority attention on work areas/shops where the greatest proportion of employees are reporting discomfort.

Scoring for the Job Factors section was designed to be as similar as possible to the scoring of the Discomfort Factors section. Consistency between sections maximizes the speed and ease of scoring. Threshold levels were set for each body area based on the consensus judgment of a team of experienced ergonomists. The threshold levels establish the number of risk factors (to which the employee is exposed) above which an ergonomist would consider performing an additional evaluation.

For example, if an employee recorded that his/her job involved three of the job factors, each for over two hours a day, the ergonomists concluded that the potential for reports of shoulder discomfort may increase -- enough to warrant additional investigation. *The consensus judgment decisions are based on approximately 45 years of combined experience in industrial and administrative area ergonomic field work.* Threshold levels are contained in Table 2.2.

Table 2.2 Job Factor Threshold Levels By Body Zone.

Body Zone	Threshold Level
Shoulder/Neck	> 2
Hand/Wrist/Arm	> 4
Back/Torso	> 2
Legs/Feet	> 1
Head/Eyes	> 1

For simplicity of scoring, each of the Risk Factor (Job Factor) questions have equal "weight." *Initial usability testing indicated that the increase in scoring complexity due to "weighting" the job factor question (e.g., high force is "worse than" stressful positions did not increase the value of the output to a commensurate level).* As is the case for the Discomfort Factors section, these individual "concerns" are converted to shop percentages to determine risk statements.

The overall Survey Priority Rank for a shop is based on the combination of the percentage of people experiencing discomfort (at a level of concern) and the percentage of people exposed to risk factors (at a level of concern). The highest priorities are given to those shops where the body areas of discomfort present correspond to the body areas of ergonomic risk factors exposure. The Discomfort Ratings are weighted more heavily than the Risk Factor Ratings when determining priority for further analysis or intervention, as is consistent with ANSI Z-365 [17]. This is reflected in the design of the Priority Matrix table which is used to determine the overall Survey Priority Rank.

A number of other factors are presented to help interpret the Survey Priority Rank and design the appropriate strategy for follow-up. The final determination of EPRA status is based on the judgment of the EWG rather than directly from a score obtained by the Survey. The EWG can evaluate the Survey Priority Ranks, the other considerations, and their knowledge of shop activities to make the final determination. The importance of integrating multiple data sources to make a decision rather than relying upon a single score has been stressed by several researchers (Drury, 1990 [25]; Kirwan & Ainsworth, 1992 [26]).

2.3.2 Scoring Process Design

The scoring process design resulted from discussions between the designers and the Air Force. Several iterations were necessary since validated methods for obtaining "risk" scores from the use of survey tools is lacking in the scientific literature. Design decisions were made to maximize ease and speed of scoring and to provide Public Health with a standardized method for comparing and prioritizing the potential risk of WMD development for all PEPA shops throughout an installation.

The scoring process is performed for each part of the Survey separately. Results are then used to determine an overall Survey Priority Rank for the shop and to help provide a recommendation for the EWG. The scoring process will be discussed in the following sections:

- Part I: Description of Work;
- Part II: Your Body's Response to Work Demands;
- Part III: Work Content; and
- Part IV: Process Improvement Opportunities.

2.3.2.1 Part I: Description of Work

Part I is divided into three sections: Risk Factor Rating, Organizational Factor Rating, and Physical Effort Score.

2.3.2.1.1 Risk Factor Rating The scoring sheet used to calculate the Risk Factor Rating is shown in **Figure 2.8**.

2.3.2.1.1.1 Rationale Criteria levels were established for each body zone based on a consensus judgment of a team of experienced ergonomists from The Joyce Institute/A Unit of Arthur D. Little, Inc. The criteria levels establish the number of risk factors (to which the employee is exposed) above which an ergonomist would consider performing an additional evaluation. For simplicity of scoring, each of the risk factor (job factor) questions have equal "weight."

2.3.2.1.1.2 Process A scoring sheet is provided for the technician to record tallies for each body zone based on individual employee responses. For example, the technician reviews the shoulder/neck job factor responses from one employee. The technician counts the number of questions that the employee responded 2-4 hours or 4-8 hours. (Check marks placed in the "0-2 hours" or "Never/NA" columns are not counted as is consistent with the OSHA draft checklist.) If the number of check marks is greater than 2, the technician makes one tally mark in the shoulder/neck tally box on the scoring sheet. The technician continues the process by reviewing the responses made by every shop employee for every other body zone. Tallies are converted into a Low, Medium, or High Risk Factor Rating.

Each body zone Risk Factor Rating is used to determine the Survey Priority Rank for the shop.

2.3.2.1.2 Organizational Factor Rating The scoring sheet used to calculate the Organizational Factor Rating is shown in **Figure 2.9**.

Figure 2.8 Scoring Sheet - Job Factors

Part I - Job Factors
A - Risk Factor Ratings (Questions 1 - 38)

Step I		Step 2	Step 3	Step 4
For each body area, count the number of responses in the 2-4 hour column and in the 4-8 hour column. **If that number exceeds the criteria number in the box in the upper right,** make one tally mark. Place only one mark per survey in each box. Write the total of the tallies in the Total box.		Divide the Total tallies by the number of surveys from one shop.	Multiply that number by 100 to get the percentage.	Write the Risk Factor Rating (Low, Med, High) in the box for each body part using the scale below. **Low Med High** ≤30% 31 - 60% 61+%
Shoulder/Neck Tally Box Questions 1-7	2	number of surveys ÷ _____ = _____ x 100 = _____%		**A.1** Shoulder/Neck Risk Factor Rating
Total				
Hand/Wrist/Arm Tally Box Questions 8-21	4	number of surveys ÷ _____ = _____ x 100 = _____%		**A. 2** Hand/Wrist/Arm Risk Factor Rating
Total				
Back/Torso Tally Box Questions 22-30	2	number of surveys ÷ _____ = _____ x 100 = _____%		**A.3** Back/Torso Risk Factor Rating
Total				
Legs/Feet Tally Box Questions 31-34	1	number of surveys ÷ _____ = _____ x 100 = _____%		**A.4** Legs/Feet Risk Factor Rating
Total				
Head/Eyes Tally Box Questions 35-38	1	number of surveys ÷ _____ = _____ x 100 = _____%		**A.5** Head/Eyes Risk Factor Rating
Total				

Figure 2.9 Scoring Sheet - Organizational Factors

Part I **B - Organizational Factor (Questions 39-44)**				
Step I	**Step 2**	**Step 3**	**Step 4**	**Step 5**
For each question that has a response of a 4-Agree or 5-Strongly Agree, make a tally in the tally box. Write the total tallies in the Total box.	Divide by 6	Divide by the number of surveys from one shop.	Multiply that number by 100 to get the percentage.	Write the Organizational Factor Rating (Low, Med, High) in the box based on the scale below: **Low** **Med** **High** ≤30% 31-60% 61+%
Tally Box 1 **Total**	÷ 6 = _____	÷ _____ (number of surveys) = _____	x 100 = _____%	**B.** Organizational Factor Rating

2.3.2.1.2.1 Rationale Responses of "Agree" or "Strongly Agree" indicate the presence of an organizational factor (e.g., "I often feel that I will not be able to satisfy the conflicting demands of various people around me") that may influence the employee's responses to the Job Factor, Discomfort, or other questions. The greater the number of responses, the higher the potential that organizational factors (or "stress") are impacting employees. Again, it should be noted that the scoring of the Organizational Factors section is based on responses from the entire group, rather than from a single employee.

2.3.2.1.2.2 Process A scoring sheet is provided for the technician to tally the Organizational Factors. For each question that has a response of "Agree" or "Strongly Agree," the technician makes a tally in the tally box. After the process has been completed for each question/for each employee, a total tally is calculated. This number is used to determine the Organizational Factor Rating of Low, Medium, or High.

The Organizational Factor Rating is not used in calculating the Survey Priority Rank for the shop.

The Organizational Factor Rating, however, can be used in interpreting the Survey Priority Rank. For example, if the shop Survey Priority Rank is a 6 because of a Low Risk Factor Rating and a High Discomfort Rating, and the Organizational Factor Rating is also High, this may indicate that the high presence of Organizational Factors may be causing employees to report a higher level of discomfort than the relatively low presence of Risk Factors indicates. (Note: this is only one interpretation. Another reason for a High Discomfort Rating, Low Risk Factor Rating, and a High Organizational Factor Rating is that many of the employees from a shop could have had

past illnesses/injuries whose symptoms have not disappeared even though the jobs have been improved to minimize the presence of risk factors.)

2.3.2.1.3 Physical Effort Score The scoring sheet used to calculate the Physical Effort Score is shown in **Figure 2.10**.

2.3.2.1.3.1 Rationale The actual numerical response is used to generate the Physical Effort Score. The higher the number/score averaged across the entire shop is, the higher the amount of physical effort that employees feel is required in that shop.

2.3.2.1.3.2 Process A scoring sheet is provided for the technician to tally the Physical Effort Score. The technician writes the actual numeric response from each Survey into the tally box on the scoring sheet. The Physical Effort Score is calculated by totaling the responses and determining the average response for the shop.

The Physical Effort Score is not used in calculating the Survey Priority Rank for the shop.

The Physical Effort Score may be used by the Air Force in post hoc analysis to determine a relationship between employee reported discomfort and perceived exertion.

Figure 2.10 Scoring Sheet - Physical Effort Score

Part I **C - Physical Effort (Question 45)**		
Step 1	**Step 2**	**Step 3**
Write the numeric score (6-20) for each survey in the tally box. Add the numbers and write the total in the total box.	Divide that total by the number of surveys.	Write the average in the Physical Effort box.
Tally Box **Total**	number of surveys ÷ _____ =	**C.** Physical Effort Score

2.3.2.2 Part II: Your Body's Response to Work Demands

Part II is divided into two sections: Discomfort Rating and General Questions Scores.

2.3.2.2.1 Discomfort Rating The scoring sheet used to calculate the Discomfort Rating is shown in **Figure 2.11**.

2.3.2.2.1.1 Rationale A Criteria Table is used to determine a tally, by body zone, for each Survey from the shop. The Criteria Table was designed based on the work of Marley and Kumar [23] and is discussed in Section 3 on pp. 3-13. Use of the Criteria Table enables the technician to "count" reports of discomfort, pain, etc. that are experienced on a daily basis, that are moderate or severe and experienced on a weekly basis, or that are severe and experienced on a monthly basis. Employees whose responses to Q46-Q60 fall into any of these categories are more likely to seek medical treatment than those who do not report lower frequency/discomfort experience.

Figure 2.11 Scoring Sheet - Discomfort Rating

Part II - The Body's Response
D - Discomfort Rating (Questions 46 - 60)

Step I	Step 2	Step 3	Step 4
For each body part, look at the responses to the second and third questions (47 & 48, 50&51, 53&54, 56&57, 59&60). If participants have answered them, then look at the Criteria Table. If the combination of answers fits one of the categories, then make a tally mark in the tally box for each body part. For example: if 47 is "weekly" and 48 is "moderate" then make a tally mark. Count and put total in Total box.	Divide the total tallies by the number of surveys from one shop.	Multiply that number by 100 to get the percentage.	Write the Discomfort Rating (Low, Med, High) in the box for each body part using the scale below. **Low** ≤30% **Med** 31 - 60% **High** 61+%

Criteria Table

	Mild	Moderate	Severe
Daily			
Weekly			
Monthly			

Shoulder/Neck Tally Box Question 46-48 **Total**	number of surveys ÷ _____ = _____ x 100 = _____%	**D.1** Shoulder/Neck Discomfort Rating
Hand/Wrist Arm Tally Box Question 49-51 **Total**	number of surveys ÷ _____ = _____ x 100 = _____%	**D.2** Hand/Wrist/Arm Discomfort Rating
Back/Torso Tally Box Question 52-54 **Total**	number of surveys ÷ _____ = _____ x 100 = _____%	**D.3** Back/Torso Discomfort Rating
Legs/Feet Tally Box Question 55-57 **Total**	number of surveys ÷ _____ = _____ x 100 = _____%	**D.4** Legs/Feet Discomfort Rating
Head/Eyes Tally Box Question 58-60 **Total**	number of surveys ÷ _____ = _____ x 100 = _____%	**D.5** Head/Eyes Discomfort Rating

2.3.2.2.1.2 Process A scoring sheet is provided for the technician to record tallies for each body zone based on responses to questions (47&48, 50&51, 53&54, 56&57, and 59&60) and use of the Criteria Table. If the combination of employee responses fits into one of the shaded categories on the Criteria Table, the technician makes a tally mark in the Tally Box. The total number of tallies is used to determine a Discomfort Rating of Low, Medium, or High for each body zone.

The Discomfort Ratings are used to calculate the Survey Priority Rank for the shop.

2.3.2.2.2 General Questions Score

The scoring sheet used to calculate the General Questions Score is shown in **Figure 2.12**.

2.3.2.2.2.1 Rationale A separate score is calculated for Q61-Q65. The Scores are:

- Health Care Provider Score,
- Recovery Time Score,
- Activity Interruption Score,
- Previous Diagnosis Score, and
- Contributing Factors Score.

Responses averaged across the entire shop provide Public Health with information against which the injury/illness documentation may be compared. For example, if the Health Care Provider Score is relatively high and there are no recorded injuries/illnesses from the group, this may indicate that symptoms of WMDs are being treated but are not being reported. This provides Public Health and/or the EWG with an opportunity to identify what the potential sources of any problems may be (Q64 and Q65 may provide additional insight).

For example, a High Health Care Provider Score, Low Previous Diagnosis and Contributing Factors Scores, and Low Risk Factor Ratings may indicate employees are experiencing problems due to outside-work activities. Also, if a High Health Care Provider Score, Low Previous Diagnosis and Contributing Factors Scores, and High Risk Factor Ratings are identified, this could indicate that employees are experiencing problems that may be work-related yet aren't being reported as work-related.

Figure 2.12 Scoring Sheet - General Questions

Part II, Continued
E - General Questions (Questions 61 - 65)

Step I	Step 2
Look at question 61 and tally only the "yes" answers in the tally box for that question. Count and write the total in the total box.	Write the total in the Health Care Provider Visit score box.

Question 61 Tally Box

Total

E.1 Health Care Provider Visit Score

Step I	Step 2	Step 3	Step 4
Look at each question and tally only the "yes" answers in the tally box for that question. Count and write the total in the Total box.	Divide the total tallies for that question by the number of surveys.	Multiply that number by 100 to get the percentage.	Write the shop percentage in the box provided.

Question 62 Tally Box

Total

E.2 Recovery Time Score

number of surveys

÷ _____ = _____ x 100 = **%**

Question 63 Tally Box

Total

E.3 Activity Interruption Score

number of surveys

÷ _____ = _____ x 100 = **%**

Question 64 Tally Box

Total

E.4 Previous Diagnosis Score

number of surveys

÷ _____ = _____ x 100 = **%**

Question 65 Tally Box

Total

E.5 Contributing Factors Score

number of surveys

÷ _____ = _____ x 100 = **%**

These scores are provided to enable Public Health and the EWG to interpret the Survey Priority Rank and other Scores to determine the appropriate follow-up action for EPRA-designated shops.

2.3.2.2.2.2 Process Again, a scoring sheet is provided. The Health Care Provider Score is determined by counting the total number of "yes" responses from the shop. The goal is to identify the total number of employees who have sought medical treatment.

For each of the other scores, the number of "yes" responses is tallied and averaged across the shop. These scores are expressed as percentages.

The General Questions Scores are not used in calculating the Survey Priority Rank for the shop.

2.3.2.3 Part III: Work Content

Responses to the Part III, Work Content section of the Survey are tallied for each "Type of Work" that employees perform on a routine basis. Tasks that are reported as routine by at least 20% of shop employees are listed on the Summary Report. Public Health and the EWG can use this information as an initial list for identifying homogeneous exposure groups.

The Work Content information is not used in calculating the Survey Priority Rank for the shop.

2.3.2.4 Part IV: Process Improvement Opportunities

Responses to the Part IV, Process Improvement Opportunities section of the Survey are not scored.

The responses, however, are recorded on the Summary Sheet for the shop and may include a listing or a summary description of hand or power tools, specific pieces of equipment, or specific tasks that employees think may be difficult to work with or to perform. Parts III and IV are not redundant. For example, the employee who marks "drilling" (Q79) as a routine task in Part III makes no indication of task difficulty. However, the employee who writes in response to Part IV-Q2 that, "drilling out rivets" is a task which requires the most effort, gives Public Health potentially highly valuable information regarding which task(s) may be exposing shop employees to ergonomic risk factors and/or causing discomfort. Employees may also provide Public Health with direct suggestions on how to improve work in the shop.

The technician is encouraged to write down every response to Part IV on the Summary Report and consider the responses as a basis for problem-solving.

Figure 2.13 Summary Report - Page 1

SUMMARY REPORT

ERPA Status:	**Priority Ranking:**	**Date:**
Date:	Workplace Identifier:	Base:
Organization:	Workplace:	Bldg./Location:
Room/Area	AFSC:	Civilian Job Series:
Shop Supervisor:	Duty Phone:	Office Symbol:

Step 1	**Step 2**	**Step 3**
Write in the **Risk Factor Rating** for Part I, (questions 1-38, Scoring Sheet pg.1)	Write in the **Discomfort Rating** for Part II, (questions 46-60, Scoring Sheet pg.3)	Look at the "Ranking Matrix" below and enter the **Priority Score** in it's corresponding box.
A.1	D.1	**Shoulder/Neck =**
A.2	D.2	**Hands/Wrist/Arms =**
A.3	D.3	**Back/Torso =**
A.4	D.4	**Legs/Feet =**
A.5	D.5	**Head/Eye =**

Ranking Matrix

Ranking Matrix for **Priority Score**	Discomfort High	Discomfort Medium	Discomfort Low
Risk Factor High	9	7	4
Risk Factor Medium	8	5	2
Risk Factor Low	6	3	1

Select the HIGHEST score for any body part from Step 3 and enter →

Survey Priority Rank:

2.3.2.5 Summary Report - Survey Priority Rank

The Summary Report consists of three pages.

2.3.2.5.1 Page 1 The first page (**Figure 2.13**) is used to identify the shop and to calculate the Survey Priority Rank for the shop.

2.3.2.5.1.1 Rationale The Survey Priority Rank for the shop is determined by combining the percentage of employees reporting discomfort (refer back to the Discomfort Rating discussion) and the percentage of employees exposed to ergonomic risk factors (refer back to the Risk Factor Rating discussion). The highest priorities are given to shops (where the body zones in which both discomfort and risk factors are present). For example, if a High Discomfort Rating and a High Risk Factor Rating were determined for the shoulder/neck area, that body part would receive a higher (9) Priority Score. If a Low Discomfort Rating and a High Risk Rating were determined for the shoulder/neck area, that body part would receive a lower (4) Priority Score.

In the Priority Matrix Table, the Discomfort Ratings are weighted more heavily than the Risk Factor Ratings. The design of this Matrix was established to reflect the Air Force philosophy that discomfort may be a stronger predictor of WMD than risk factor exposure.

A Priority Rank of 5 or higher should be considered as EPRA status.

2.3.2.5.1.2 Process Priority Scores are determined for each body zone by transferring Discomfort Ratings and Risk Factor Ratings to the Summary page. The Ranking Matrix is then used to identify the Priority Score. The process is repeated for each of the body zones. The highest Priority Score for any body zone becomes the Survey Priority Rank for the shop.

2.3.2.5.2 Page 2 The second page (**Figure 2.14**) is used to summarize the Organizational Rating, Physical Effort Factor, and General Questions scores, as well the results from Part III of the Survey.

2.3.2.5.2.1 Rationale Much of the rationale behind the use of the Organizational Rating (item B), Physical Effort Factor (item C), General Questions scores (items E.1-E.5), and results from Part III (item F) was previously discussed. The combined information is used to add depth to the Survey Priority Rank. The information enables Public Health and the EWG to interpret the Survey Priority Rank, which reflects only the Discomfort Rating and Risk Factor Rating, based on all of the factors to which employees in a shop may be exposed.

All of the information must be considered when making conclusions and recommendations for the shop.

Figure 2.14 Summary Report - Page 2

Step 4	
B. Enter **Organizational Rating:** (Questions 39-44, Scoring Sheet pg. 2)	**Comments:**
Step 5	
C. Enter **Physical Effort Factor Score**: (Question 45, Scoring Sheet pg.2)	**Comments:**
Step 6	
E. Enter the score for each of the **General Questions**: (Questions 61-65, Scoring Sheet pg. 4)	
E.1 Health Care Provider Score _____ %	**Comments:**
E.2 Recovery Time Score _____ %	**Comments:**
E.3 Activity Interruption Score _____ %	**Comments:**
E.4 Previous Diagnosis Score _____ %	**Comments:**
E.5 Contributing Factors Score _____ %	**Comments:**

Step 7

F. List below each of the routine types of work which had shop percentage scores over 20%. (Items 66-122, scoring sheet page 5)

Type of Work	**%**	**Type of Work**	**%**
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

2.3.2.5.2.2 Process Scores for Organizational Rating, Physical Effort Factor, General Questions, and Work Content are transferred from the tally sheets to the Summary Sheet. The technician is encouraged to provide an interpretation of the ratings/scores in the Comments column.

From the Work Content section of the Scoring Sheets, the technician generates a list of routine tasks that were identified by at least 20% of shop employees

2.3.2.5.3 Page 3 The third page (**Figure 2.15**) contains the remaining Scoring Summary information.

2.3.2.5.3.1 Rationale Three types of information are provided on page 3 of the Summary Report: Potential Concerns, Potential Improvement Opportunities, and Injury/Illness Data. Conclusions and Recommendations are based on a consideration of the Survey Priority Rank and the balance of information on Summary Report pages 2 and 3.

2.3.2.5.3.2 Process From Part IV of the Survey, the technician generates a list or descriptive paragraph of potential ergonomic concerns (e.g., tasks, tools, equipment, etc.) and/or improvement opportunities.

From a review of the AF Form 190s, illnesses/WMDs that have been reported in the shop for the past three years are listed in the Comments column. Public Health is encouraged to copy the relevant Form 190s and attach the forms to the Summary Report.

The Conclusions and Recommendations Summary is to be completed by the EWG. The EWG will make a determination of EPRA status (or not) based on the Survey Priority Rank, the ratings and scores for the other factors, and the interpretation provided by Public Health.

The Conclusions and Recommendations Summary should also indicate the intended follow-up action for the shop.

This information enables Bioenvironmental Engineering Services to proceed with a Level 1 evaluation, if appropriate.

Figure 2.15 Summary Report - Page 3

Step 8	
Review Part IV (Questions 1-3) to identify tasks, tools, equipment, etc., that employees listed as potential concerns. Comment as appropriate.	**Comments:**
Review Part IV (Question 4) to identify potential improvement opportunities. Comment as appropriate.	**Comments:**
Step 9	
Injury/Illness Data: Review the injury/illness history from this shop. Attach information and comment as appropriate.	**Comments:**

Step 10
Conclusions / Recommendations Summary

Shop Status

Recommendations for follow-up:

3.0 SURVEY TESTING AND VALIDATION PROCESS

3.1 Overview of Testing and Validation Process

The purpose of the validation process is to:

- establish the strengths and limitations of the Survey; and
- identify the need for changes based on quantitative information.

A variety of techniques have been used by researchers to validate ergonomic assessment tools. A review of techniques is presented in **Table 3.1.**

Table 3.1 Techniques Used to Validate Ergonomics Assessment Tools

Reference	Validation Techniques
Keyserling et al, 1993 [2]	• Novice checklist vs. Expert detailed analysis (concurrent validity)
Stetson et al, 1991 [27]	• Inter-rater agreement (reliability)
Lifshitz & Armstrong, 1986 [13]	• Checklist score vs. Incidence rate (predictive validity)
Kemmlert, 1994 [12]	• Comparison with another scale (concurrent validity) • Items based on literature (content validity) • Inter-rater agreement (reliability)
Engkvist et al, 1995 [28]	• Inter-rater agreement (reliability)
McAtammey, 1993 [14]	• Checklist score vs. discomfort (predictive validity) • Inter-rater agreement (reliability)
Cole, 1995 [1]	• Test/re-test consistency (reliability) • Checklist score vs. job type (concurrent validity)
Silverstein et al, 1991 [29]	• Student score vs. expert score, same checklist (reliability, usability)
Baron et al, 1996 [8]	• Test/re-test consistencies, inter-item correlation (reliability) • Assessment results vs. physical exam (predictive validity)

Based on the techniques reported in the literature, the process used to validate the effectiveness of the Survey was comprised of three distinct steps:

- usability testing;
- test/re-test reproducibility; and
- concurrent validity testing.

3.2 Methods

3.2.1 Usability Testing

Usability testing was performed to insure that the end users would be able to administer the Survey as it was designed and according to Air Force objectives. Usability testing focused on both the survey questions and the scoring procedures. The usability testing was performed at Malmstrom AFB. A group of 25 Air Force personnel from a variety of shops completed the Survey and participated in a focus group. During the focus group, employees commented on the clarity and appropriateness of questions to Air Force operations. The Public Health staff completed the scoring process and commented on the scoring methodology.

3.2.2 Reproducibility Testing

The purpose of reproducibility testing is to determine how consistently a survey tool produces the same results. Reproducibility testing generally determines the upper limits of the effectiveness of a tool. A tool can not be better than the degree to which it consistently obtains the same results.

Reproducibility testing is generally performed one of several ways. Inter-rater reproducibility examines the similarity of results obtained by different raters. For instance, if two people use a tape measure to determine the length of an object, the degree to which they agree on the length demonstrates inter-rater reproducibility. Another form of reproducibility is the degree to which a person provides the same response at different times. This is referred to as test/re-test reproducibility. Test/re-test reproducibility is the preferred method for self-reporting tools since each person's actual experience, as well as perception, may vary.

Test/re-test reproducibility was conducted for the Survey since it is a self-reporting tool.

3.2.2.1 Study Group

The contractor performed a two-week pilot test/re-test study at Peterson AFB. The primary purpose of the pilot study was to determine if the participants could consistently answer the Survey questions. A two-week interval was chosen to ensure sufficient delay so that participants would not remember their responses while maintaining a short enough interval that the participant's job demands and discomfort would remain constant [31]. In order to determine a

sample size estimate, the statistical power for a Pearson correlation was utilized with a desired power of .95 (assuming a correlation of .5 and alpha of .05). Test planning called for 50 participants from shops with known or suspected ergonomic hazards and additional participants from shops known to have minimal risk to serve as a control group. As many as 75 to 100 participants were expected for the initial Survey administration. Fifty employees from five shops participated. Forty participants returned for the second Survey administration. Twenty-seven of the 40 participants were from shops with known or suspected ergonomic hazards. The data for the participants who did not participate in the second Survey administration was removed before conducting analyses.

Participants were assured of the anonymous nature of the survey. The tracking of surveys between sessions was conducted using random code numbers known only by the individual participants. This anonymity was important to facilitate accurate responding and to produce an environment similar to the environment expected during actual use of the survey tool.

Due to budgetary constraints, the number of shops that participated in the pilot investigation was limited. The shops did represent a variety of Air Force tasks; however, the sample size was not sufficient to capture the full diversity of tasks found throughout Air Force operations. As a result, the personnel who took part in reproducibility testing are not considered to be completely representative of all personnel who would be completing the Survey after its use is adopted.

The combination of the small sample size of persons from shops with ergonomic hazards and the non-representative nature of the sample group resulted in very low response rates to some questions. As a result, 14 of the 38 risk factor questions may not have had sufficient response rates of risk factor presence to make any definitive reproducibility statements. It is possible that the tasks performed in these shops did not involve the risk factors depicted in these 14 questions. However, since the questions were obtained from validated sources and were either incorporated into the Survey in their original form or modified slightly, it is expected that the questions remain reproducible. The questions with low response rates are listed in the reproducibility results table without accompanying statistics but with a note of the number of responses greater than 2 hours. The reproducibility results should be interpreted cautiously in consideration of the non-representative nature of the sample. **Table 3.2** lists the number of participants by shop.

Table 3.2 Shop Participants for Test/Re-Test Evaluation

Shop	Number of Participants
Bioenvironmental Engineering Services and Public Health (Control shops)	13
Dental Lab	12
Falcon AFB (Training Group)	7
Structural Maintenance (Heavy duty maintenance/repair aircraft)	5
Survival Equipment Repair	3

3.2.2.2 Statistical Analyses

A variety of statistical methods have been reported in the literature for measuring reproducibility, including: percent agreement, correlation's, coefficient of concordance, chi-square, and Kappa. Meister [30] provides an overview of each of these reproducibility methods with comments regarding their practical utility for behavioral analysis methods. Meister concludes that each method has certain limitations and that no single measure of reproducibility is agreed upon.

The selection of the Kappa statistic was based on its relative ease of interpretation and comparability to the reproducibility results obtained by Wiktorian et al [31]. These factors make the Kappa a good choice for reporting the reproducibility results.

In order to compare the two administrations of the Survey, a weighted Kappa was performed. (Cohen, 1960 [32]; Fleiss & Cohen, 1973 [33]; Bartko & Carpenter, 1976 [34]). The weighted Kappa compared the survey responses for each Survey administration. *Since it is expected that a certain amount of agreement would occur by chance, such as having 50% correct on a true/false test, the Kappa statistic reports agreement after chance has been removed. A Kappa value can be interpreted as a percent of agreement. For instance, a Kappa of .75 indicates an agreement rate of 75% after chance has been removed.*

A 95% confidence interval is reported for each Kappa. Because statistical testing uses a smaller sample to predict the actual results of a larger population, the actual population results may be different than the sample results. The confidence interval reports a range in which the population results could reasonably be expected to fall. The confidence interval is affected by sample size and variability. A small sample size, such as the Survey reproducibility testing, results in a larger range for the confidence interval. When the lower bounds of the confidence interval were below chance agreement (Kappa < 0.0), it suggests that the agreement reported by the Kappa obtained from the test group may not reflect an agreement above the chance level for the population.

In terms of the true/false test scenario presented previously, if a test had 100 questions it would be difficult to predict the whole test score based on knowledge that seven of ten questions were

answered correctly. The prediction of whole test scores would improve with knowledge that 35 of 50 questions were answered correctly. Although the proportion of agreements (test answers with correct answers) is the same in each case, in the second scenario more accurate estimates can be made. A confidence interval is a numerical reporting of this prediction accuracy. As a means of better understanding Kappa values, assuming an equal overall ratio of true and false responses, the Kappa value for each of the above scenarios would be .40.

The Kappa values were calculated for each individual Survey question, as well as for the body area section scores for the Job Factors and Discomfort Factors sections of the survey. When responses were not dichotomous, a weighted Kappa, with squared deviations from agreement as weights, was used as suggested by Maclure and Willett, 1987 [35]. The contractor used SAS version 6.11 for Windows to complete the analyses. **Table 3.3** provides a summary of the guidelines which were used to interpret the Kappa values.

Table 3.3 Guidelines for Interpreting Kappa Values

Kappa Values	Interpretation
.81 to 1.0	Almost Perfect
.61 to .80	Substantial
.41 to .60	Moderate
.21 to .40	Fair
0.0 to .20	Slight
< 0.0	Poor

The interpretations provided in Table 3.3 are consistent with those suggested by Landis and Koch (1977) [36]. In order to conclude that modifications to questions did not substantially alter previous validations of these questions, results were expected to be similar to those obtained by Wiktorian et al [31]. Because of the small sample size, the findings are considered indicative of similarity to previous research findings rather than definitive statements of reproducibility. The Kappa values obtained by Wiktorian et al [31] for working postures and material handling descriptors generally ranged between .35 and .50 with the lower confidence interval (95%) typically above .25 and the upper confidence interval below .55. On the combined basis of the descriptive interpretations [36] and the previous findings [31], the obtained values of Kappa were expected to fall in the "moderate" range suggesting that the modified questions retained similar reproducibility to the original questions. When Kappa values were below .40, or when the lower range of the confidence interval was below .20, it was determined that the reproducibility of these questions may be lower than the initial questions. Explanations of the lower reproducibility values were investigated and, when needed, modifications to the question were considered.

Since the Organizational Factors used a 5-point Likert scale for responses, several analyses were conducted to describe the data. The weighted Kappa was performed on the 5 point responses for consistency with the other Factors. Because the scoring is based on the occurrence of agree or

strongly agree (with no distinction between these two responses) the data was split between agree and the combination of neutral and disagrees. A Kappa was performed comparing these two levels and reported as a "2 level Kappa." Likert scales can generally be considered as interval type data (Meister) and, as such, the Pearson correlation is presented as a measure of association.

Missing values (non-responses) for individual questions in the Job Factors questions were coded the same as "zero hours daily" responses. Since a "never" category did not exist, this coding is consistent with the manner in which these responses would be scored by technicians when administering the survey. While treating a blank response as a non-existence of the risk factor may lead to a statement of lower ergonomic risk within a shop, it appears to be the most consistent method for selecting a score for the survey. Since this was a pilot study with a low sample size, eliminating these subjects from the analysis would have greatly reduced the ability to obtain or interpret results. The Job Factors questions have been modified to include a "never" response which should greatly reduce the number of blank survey responses.

A post hoc comparison was conducted on the shop level scores using a Spearman rank order correlation as a pilot investigation of the reproducibility of shop level scores. The Spearman correlation was selected based on the rankings nature of the data. It is assumed that the Priority Ranks provided as output from this tool provide information of an ordinal nature rather than an interval nature. Existing research provides minimal insight into reproducibility at this level. While the sample size of five shops resulted in a relatively low power, the results are presented as an initial indication of shop level reproducibility.

3.2.3 Validity Testing

Once the reproducibility of a tool has been established, the meaning of the answers needs to be evaluated. In research terms this is called validity. There are several types of validity. The most stringent is predictive validity. *A college may base its admission decisions largely on previous GPA because research and experience has shown that the best predictor of future academic performance is past academic performance. This is an example of predictive validity*. Predictive validity is rare in ergonomic assessment tools.

A more common validity measure in ergonomics is concurrent validity. Concurrent validity uses one type of measure to validate another measure. For instance, oxygen consumption might be measured to validate a metabolic expenditure model. This is the type of validation that was performed on the Survey. A Masters degree-level (M.S. in Industrial Engineering) Ergonomist was selected as the "Ergonomist Expert" based on his previous experience with the types of work found throughout the Air Force. The results of the Ergonomist's assessment of shop activities would be compared against the results obtained from the Survey method. The similarity of rankings would determine how much the two measures agree with each other. An extensive review of the research literature did not provide any previous studies of this specific relationship to predict what degree of correlation to anticipate between an Ergonomist ranking of shops and a Survey ranking of shops. The contractor estimated the correlation between .5 and .7 prior to conducting validity testing based on data regarding inter-rater agreement at the job level. This

estimate was used to establish sample size requirement and to specify the objectives of the Survey.

3.2.3.1 Procedures (e.g., Ergonomist analysis vs. Survey results)

The Ergonomist visited 31 shops (26 shops at Patrick AFB and 5 shops at Cape Cod AS) two weeks prior to the administration of the Survey. The two-week time period was established to minimize the potential that employees would respond to a Survey question based on discussions that may have occurred during the Ergonomist's shop visits and to minimize the possibility of significant changes in the tasks performed by shop personnel. The Ergonomist was intentionally kept blind to the rationale, development, content, and scoring of the Survey. During the shop visits, the Ergonomist identified himself as a "safety contractor" to limit the potential for biasing the subsequent Survey administration.

While visiting the shops, the Ergonomist obtained an overview of activities within each shop, completed an independent ergonomic assessment on selected representative tasks, and reviewed the injury and illness records for the shop. The Ergonomist was instructed by the Survey designers to provide (1) a risk statement for each of the five body areas used in the Survey, (2) an overall risk rating for the shop, and (3) a relative ranking of shops (e.g. list of shops from greatest to least amount of risk factor exposure.

The contractor instructed base personnel from Patrick AFB and Peterson AFB (in cooperation with Cape Cod AS) in the Survey administration. The importance of an 80% response rate from shops was emphasized verbally and repeated in the written Survey administration instructions. The contractor participated in the administration and scoring of the Survey at two Patrick AFB shops in order to demonstrate the complete process. Survey administration and scoring for the remaining shops was conducted by base personnel. As planned, the Survey was administered at least two weeks after the Ergonomist's shop visits. Shop scoring was performed by Air Force personnel, and the results were provided to the contractor for analysis. A response rate of at least 80 percent was obtained from 18 of the 31 shops. However, in 13 shops the response rates were below 80%.

3.2.3.2 Statistical Analyses

The body area Risk Factor Ratings, Priority Scores, and Survey Priority Rank obtained using the Survey were compared to the Ergonomist's findings using a Spearman rank-order correlation. The agreement between the Survey body area Risk Factor Ratings and the Ergonomist's body area risk ratings were calculated using a weighted Kappa.

3.3 Results

3.3.1 Usability Testing

The results of the usability testing indicated that the length of time to administer and score the survey exceeded the project goals. The completion of the Survey administration required one

hour and 20 minutes. The scoring requirements for a shop of 25 people were extrapolated from smaller data sets. When it became apparent that the scoring process was taking significantly more time than was allocated, the number of Surveys scored by each person was reduced to five or fewer Surveys per person. An extrapolation of the data indicated that scoring a shop of 25 people would take between 6 and 8 hours.

3.3.1.1 Survey Design Feedback

At the time of the usability testing, the alpha-version Survey design included separate sections for administrative, warehouse, assembly, and maintenance/inspection work types. Participants indicated that they did not know which sections (e.g., one?, more than one?) they were supposed to complete. Also, some participants felt that if they were exposed to a risk factor for 2 hours and they responded in the "0-2 hours" category, they would be counted the same way as a person who was never exposed to a risk factor. Conversely, participants who were never exposed to a risk factor felt that by responding in the "0-2 hours" category, they would be overstating their exposure.

3.3.1.2 Scoring Process Design Feedback

The alpha-version Survey scoring included relative importance weightings for risk factors. During the scoring, Public Health representatives commented that the scoring and weighting processes were confusing and too time consuming.

3.3.1.3 General Comments on Administration

The users and future administrators also commented that the Ergonomics Overview was too long and that it should be limited to providing information only on the purpose for completing the survey, how the results will be used, and the survey instructions.

3.3.1.4 Changes Made to Improve Usability

Based on the feedback, the following changes were made:

- the overview was reduced and limited to providing information on purpose, outcome, and instructions;

- the number of questions was reduced;
- redundancy was eliminated by combining the general and area specific questions into one Job Factors section;

- a "never" response category was added to parts I and III of the Survey as a result of this feedback;

- the amount of hand tallying was reduced; and

- weightings for individual risk factor questions was eliminated since the difficulty in scoring far exceeded the expected value of weighting for discriminating between shops.

One additional usability request made by the administrators of the Survey during reproducibility testing at Peterson AFB was the inclusion of written instructions which would allow the option of "dropping-off" the blank Surveys and asking shop personnel to complete the Surveys without any introductory remarks. This request, however, was not adopted because of the potential for poor response, loss of completed Surveys, etc., and to avoid creating misconceptions about the purpose and use of the Survey results.

3.3.2 Reproducibility Testing

3.3.2.1 Section Tally Results

During the scoring of a shop, each survey is reviewed and a yes/no decision is made regarding a tally for each of the five body zone Job Factors and Discomfort Factors sections. These ten tally marks are the only risk factor and discomfort information used from the individual surveys to establish shop scoring. Agreement at this level has a greater impact on the shop scoring than does the agreement to individual questions. Poor agreement or non-significant results at the tally level demands greater attention.

Table 3.4 shows the actual agreement rates, weighted Kappa values, and 95% confidence intervals for each of the section tallies. Eight of the ten tally sections had agreements in the fair to good range. In the tally sections for the back/torso, both the Job Factors and Discomfort Factors displayed lower agreement rates. The low weighted agreement rates may be a by-product of a low number of back-intensive jobs in the sample group. Less than five people responded to questions in a manner that would lead to a tally for the back/torso in either of the two Survey administrations. Ratings for leg discomfort appear to be more variable than the other body areas. The agreement rates (not chance corrected) were consistently above 80%. The high raw agreement rates combined with the lower Kappa values reflect the high degree of responses in one category. Since the chance agreement is high, the chance corrected agreement (Kappa) is naturally lower.

Table 3.4 Test/Re-test Agreement--Section Tallies

Tally	Raw % Agreement	Weighted Kappa	95% LCI	95% UCI	Comments
Shoulder Risk Factor Tally	80%	.429	.099	.758	
Hand/Wrist Risk Factor Tally	88%	.679	.424	.935	
Back/Torso Risk Factor Tally	90%	.286	-.214	.785	Low Kappa value may be due in part to the limited number of back-intensive jobs in the test sample
Legs/Feet Risk Factor Tally	80%	.60	.364	.836	
Head/Eyes Risk Factor Tally	80%	.467	.151	.782	
Shoulder Discomfort Tally	83%	.573	.292	.854	
Hand/Wrist Discomfort Tally	88%	.679	.424	.935	
Back/Torso Discomfort Tally	83%	.364	-.006	.733	Low Kappa value may be due in part to the limited number of back intensive jobs in the test sample
Legs/Feet Discomfort Tally	95%	.474	-.148	1.095	The upper CI exceeds 1.0 due to the large variance of Kappa.
Head/Eyes Discomfort Tally	85%	.571	.268	.875	

3.3.2.2 Job Factor Question Results

Job Factor question results are provided in **Table 3.5**. Due to the nature of the sample population, many questions had low response rates in the categories above 2 hours per day. The high prevalence of responses, over 90% of respondents in some cases, in the less than 2-hour category created a situation where a single response disagreement could greatly reduce the Kappa value. When a Kappa value could not be computed due to an uneven distribution of the data, no figures are reported in the table. When the average number of responses from the test and re-test conditions was less than five, the number of responses is recorded in the comments section. The Kappa values are not reported when response rates were less than 5 to avoid drawing unwarranted conclusions.

Based on the limited number of personnel and job categories that were available for the test, the following preliminary interpretation is provided. For those questions with sufficient response rates, most questions had sufficient high agreement to include confidently. A total of 38 questions were developed. Eighteen (47%) were tested using the weighted Kappa statistic. Of

the 18 tested, 16 (89%) either met or exceeded the goal of .40, furthermore 15 of the questions had lower confidence intervals of .199 or higher. The Kappa results suggest that the revised questions had similar reproducibility rates as previously published results [31]. The raw agreement percentages indicate that most questions (28/38) had agreement rates higher than 80%. Therefore, while the sample size is small, this result suggests that modifications to the questions did not have any negative affects on the reproducibility and may have improved the reproducibility of some questions. A much larger sample size would be required to firmly establish reproducibility and to determine if the reproducibility of some questions had been substantially improved. Sample size is an important contributing factor to a low variance (and therefore confidence intervals that are close to the actual score). The small sample size in this pilot test may have contributed to large confidence intervals, which limits the ability to make definitive statements regarding the reproducibility of items in this scale. The Kappa values and raw agreement percentages suggest a moderate level agreement, similar to existing scales.

The less than perfect Kappa agreement should be interpreted in light of previous research on working postures questions [31] which demonstrated agreement rates between .32 and .68, as well as research on self-reporting in general which indicates reproducibility Kappa's as low as .43 for "have you ever taken vitamins?" and .62 for "do you drink coffee?" (Kelly, Rosenberg, Kaufman and Shapiro, 1990 [37]). Furthermore, the raw agreement rates were consistently above 80%, indicating a substantial agreement between testing sessions.

Table 3.5 Weighted Kappa Statistics for Job Factor Questions

Question	Raw % Agreement	Weighted Kappa	95% LCI	95% UCI	Comments
1. hands at or above chest level	75%	.584	.342	.827	
2. lay on back or side	100%				0 responses > 2 hrs
3. hold or carry materials	88%				3 responses > 2 hrs
4. force or yank components	88%				2 responses > 2 hrs
5. reach or hold arms in front of body	70%	.603	.398	.807	
6. neck is tipped	50%	.444	.220	.669	
7. cradle a phone	85%				4 responses > 2 hrs
8. wrists are bent	70%	.444	.209	.679	
9. apply pressure for more than 10 seconds	80%	.773	.627	.919	
10. similar to clothes wringing	78%	.055	-.20	.311	Question clarified for current version
11. repetitive tasks	70%	.632	.440	.824	
12. red marks on skin	83%	.472	.159	.785	

Table 3.5 Weighted Kappa Statistics for Job Factor Questions (Contd.)

Question	Raw % Agreement	Weighted Kappa	95% LCI	95% UCI	Comments
13. hand as a hammer	93%				2 responses > 2 hrs
14. fingers are cold	85%				3 responses > 2 hrs
15. incentive or quota	80%	.619	.362	.875	
16. tools vibrate or jerk	80%	.505	.211	.798	
17. throw or toss	98%				1 response > 2 hrs
18. twist forearms	85%	.556	.199	.912	
19. bulky gloves	98%				3 responses > 2 hrs
20. hand pressure	95%				1 response > 2 hrs
21. pinch grip tightly	73%	.684	.511	.856	
22. hands below knees	100%				0 responses > 2 hrs
23. lean forward continually	70%	.566	.343	.790	
24. PPE restrictive	93%				3 responses > 2 hrs
25. repetitive back movements	78%				Non-square
26. lifting twisted or quickly	98%				1 response > 2 hrs
27. whole body vibration	100%				2 responses > 2 hrs
28. 1-hand lift/carry	100%				Non-square
29. lift bulky items	93%				2 responses > 2 hrs
30. lift more than 25 lbs.	93%				3 responses > 2 hrs
31. kneel or squat	95%				4 responses > 2 hrs
32. apply foot pressure	88%	.576	.277	.875	
33. feet off floor	83%	.316	-.01	.641	Illustration modified
34. stand on hard surfaces	75%	.626	.412	.840	
35. glare	83%	.710	.515	.904	
36. noise	75%	.560	.341	.779	
37. vigilance	93%				2 responses > 2 hrs
38. lighting	88%				3 responses > 2 hrs

Based on the results of the reproducibility testing, several questions were re-worded to improve clarity. An illustrative figure was added to questions 7 and 10. The wording was modified for question 20. The illustration for question 33 was also modified.

3.3.2.3 Organizational Factors and Physical Effort Scales Results

For the Organizational Factors questions (Q39 - Q44), a weighted Kappa is reported for the entire 5 level scale where possible. A dichotomous response grouping was also created for the Organizational Factors questions comparing the "agree" responses with the "neutral" and "disagree" responses. This is reported as a two-level Kappa under the comments column in **Table 3-6**. The results of a Pearson correlation are also presented for the psycho-social and Borg scale questions.

The responses to the Organizational Factor questions were among the most consistent for the entire survey. Six organizational factors questions were developed and all six (100 %) had sufficient response rates to be tested. All of the questions (100%) had Kappa values that exceeded the goal of .40 with lower confidence intervals above .33.

The two-level Kappa's generally suggested "substantial" agreement. The Kappa values were closer to the raw agreement data for these questions because the response were more evenly distributed across categories (which produces a lower chance agreement rate correction in the Kappa formula). The higher degree of reproducibility in the organizational questions compared to the job factor questions may reflect the nature of the questions (the questions may be easier for people to respond to) or the more familiar response scale of strongly agree to strongly disagree.

Table 3.6 Weighted Kappa Statistics for Organizational Factors and Physical Effort Questions

Question	Raw % Agreement	Weighted Kappa	95% LCI	95% UCI	Comments
39. unclear responsibilities	65%	.590	.373	0.67	r = .67/2 level Kappa .68 CI .35 to 1.02
40. heavy workload	58%	.624	.459	.789	r = .74/ 2 level Kappa .70 CI .45 to .94
41. conflicting demands	60%				r = .79/ 2 level Kappa .73 CI .49 to .98
42. unable to get information	70%				r = .69/ 2 level Kappa .61 CI .33 to .89

Table 3.6 Weighted Kappa Statistics for Organizational Factors and Physical Effort Questions (Contd.)

Question	Raw % Agreement	Weighted Kappa	95% LCI	95% UCI	Comments
43. supervisor feedback	58%				r = .68/ 2 level Kappa .62 CI .29 to .95
44. amount of work interferes with quality	70%	.464	.276	.653	r = .64/2 level Kappa .63 CI .36 to .90
45. Borg scale					r = .78/non-square

3.3.2.4 Discomfort Factor and General Questions Results

The Discomfort Factor questions, with the exception of back/torso, demonstrated generally "moderate" or "substantial" agreement, with most Kappa values near or above .60 and lower confidence intervals above .20. The variability in back/torso discomfort scores may have been the result of the limited number of back-intensive operations within the sample group. A total of 20 questions were developed. Eighteen (90%) were tested, two had high variability. Of the 18 tested, 16 (89%) had Kappa values greater than .40.

The agreement rates are similar to those obtained by Dickinson et al [24] who reported agreement rates (not chance corrected) of .74 to .94 for yes/no questions regarding discomfort frequency. The agreement rates (not chance corrected) for the yes/no questions regarding the occurrence of discomfort ranged from .78 to .90 in this pilot test. The agreement rates for the general questions regarding discomfort severity and pre-existing conditions were similarly high with agreement rates between .85 and 1.00. Results are presented in **Table 3.7**.

The test/re-test reproducibility for the Discomfort Factors section of the Survey is similar to that of other discomfort survey tools found in the literature. This suggests that the modifications made to existing questions for inclusion in the Survey did not negatively impact the reproducibility of the questions.

Table 3.7 Weighted Kappa Statistics for the Discomfort Factor and General Questions

Question	Raw % Agreement	Weighted Kappa	95% LCI	95% UCI	Comments
46. Shoulder/Neck Occurrence	83%	.646	.411	.881	
47. S/N Frequency	75%	.629	.406	.852	
48. S/N Severity	68%	.491	.247	.735	

Table 3.7 Weighted Kappa Statistics for the Discomfort Factor and General Questions (Contd.)

Question	Raw % Agreement	Weighted Kappa	95% LCI	95% UCI	Comments
49. Hand/Wrist/Arm Occurrence	85%	.698	.476	.920	
50. H/W/A Frequency	65%	.657	.484	.830	
51. H/W/A Severity	63%				Non-square
52. Back Torso Occurrence	78%	.529	.263	.795	
53. B/T Frequency	78%	.371	.145	.598	High response variability
54. B/T Severity	63%	.340	.078	.603	High response variability
55. Legs/Feet Occurrence	90%	.608	.259	.957	
56. L/F Frequency	83%	.587	.288	.886	
57. L/F Severity	85%				Non-square
58. Head/Eyes Occurrence	85%	.681	.448	.914	
59. H/E Frequency	73%	.579	.345	.812	
60. H/E Severity	73%	.524	.276	.773	
61. Health care visits	95%	.724	.366	1.082	
62. Discomfort not improving	93%	.754	.490	1.018	
63. Interference with activities	85%	.601	.316	.887	
64. Previous diagnosis	88%	.474	.081	.867	
65. Contributing conditions	100%	1.00	1.00	1.00	

3.3.2.5 Work Content (Part III)

During the reproducibility testing sessions the administrators noticed that some participants were unclear about how to respond to tasks which they did not perform. While the original Administrator's Script instructed participants to "leave blank" tasks that they "never" performed, some participants continued to respond to all tasks (e.g., some answered "non-routine" and several answered "seasonal"), despite the instructions. It also appears that some participants selected a different response choice for these tasks in the re-test administration. The resulting

weighted Kappa values were typically in the poor to fair range, generally between .25 and .45. The results are presented in **Table 3.8**.

A "never" category was added to the Survey after the completion of reproducibility testing. The agreement on the revised tool is expected to be considerably higher as a result of this modification.

Table 3.8 Weighted Kappa Statistics for Work Content

Question	Raw % Agreement	Weighted Kappa	95% LCI	95% UCI
66.	28%	.132	.096	0.360
67.	98%	. 952	.861	1.043
68.	75%	.666	.471	.862
69.	28%	.141	-0.010	.293
70.	60%	.442	.224	.661
71.	58%	.417	.186	.647
72.	50%	.244	.002	.487
73.	68%	.560	.349	.771
74.	88%			
75.	28%	.125	-.071	.321
76.	95%			
77.	73%	.513	.275	.751
78.	73%	.618	.419	.817
79.	48%	.290	.061	.519
80.	50%	.338	.098	.578
81.	95%			
82.	60%	.476	.245	.709
83.	70%	.370	.085	.655
84.	50%	.294	.047	.542
85.	55%			
86.	65%			
87.	58%	.447	.225	.670
88.	53%	.374	.144	.603
89.	58%	.327	.068	.587

Table 3.8 Weighted Kappa Statistics for Work Content (Contd.)

Question	Raw % Agreement	Weighted Kappa	95% LCI	95% UCI
90.	60%	.389	.136	.642
91.	63%	.384	.125	.643
92.	73%	.438	.156	.719
93.	65%	.494	.261	.726
94.	70%	.516	.265	.767
95.	55%	.323	.064	.581
96.	78%	.701	.508	.895
97.	70%	.413	.131	.695
98.	58%	.318	.057	.579
99.	65%	.476	.225	.727
100.	68%	.485	.221	.749
101.	70%	.412	.121	.703
102.	65%	.509	.262	.756
103.	65%	.337	.049	.625
104.	68%	.530	.284	.776
105.	60%			
106.	65%	.446	.183	.709
107.	65%			
108.	70%	.525	.269	.781
109.	58%	.326	.054	.599
110.	55%	.450	.218	.681
111.	58%	.295	.012	.578
112.	63%	.402	.127	.677
113.	68%	.507	.250	.764
114.	60%			
115.	58%			
116.	63%	.456	.200	.711
117.	70%	.400	.106	.694
118.	63%	.384	.106	.662

Table 3.8 Weighted Kappa Statistics for Work Content (Contd.)

Question	Raw % Agreement	Weighted Kappa	95% LCI	95% UCI
119.	58%	.340	.074	.605
120.	53%			

3.3.2.6 Shop Level Scores

A post hoc comparison was made between the test and the re-test condition for the priority scores and the Survey Priority Rank at the shop level using a Spearman correlation. This comparison provides preliminary information regarding the consistency of scores at the shop level. The limited number of shops involved (5 shops) resulted in relatively low power (estimated power less than .30).

Participants who were not present for both administrations were removed from the shop scoring for the analysis. The power was weak for this analysis because only five shops were represented. Furthermore, the opportunity for variance was high because two of the shops had a low number of participants. The Structural Repair Shop had five participants and the Survival Equipment Repair Shop had three participants. Since the Survey scores are based on the percent of respondents, the scores can be greatly influenced by one person's response in smaller shops. In spite of the limitation, the preliminary results are promising. The relative risk ranking remained similar between both Survey administrations. The recommendations regarding EPRA status was unchanged for each shop across the two administrations. These results are sufficiently promising to encourage additional testing of shop level reproducibility using a sample size of approximately 25 shops. The shop Survey Priority Rankings were determined and are presented in **Table 3.9**.

Table 3.9 Test/Re-Test Shop Priority Rankings Compared

Shop	Test Rank	Re-Test Rank
Dental Lab	7	7
Structural	5	7
Survival Equipment	7	5
Falcon	2	2
Bio/PH	2	1

The data also suggests that the rank-order of body areas priority scores remained consistent from the test session to the re-test session for all priority scores except for the head/eyes. In spite of the power limitations, these results are promising. The results of the Spearman correlation on the priority scores and final ranking score are provided in **Table 3.10**.

Table 3.10 Spearman Correlation Between Priority and Final Ranking Scores

Body Area	Spearman	Probability
Shoulder/Neck	1.00	.000
Hand/Wrist/Arm	.82	.086
Back/Torso	1.00	.000
Legs/Feet	.65	.237
Head/Eyes	-.02778	.965
Survey Priority Rank	.73	.161

3.3.3 Validity Testing

The correlation between the overall shop rankings determined by the Ergonomist and the Survey Priority Rank produced by the Survey demonstrated a statistically significant correlation ($p < .03$), although the correlation obtained, .39, was lower than the estimated .5 to .7. The ergonomist determined that 20 of the 31 shops could be designated as "problem/EPRA" shops (e.g., high, high/medium). The Survey indicated that 17 of 31 shops could be designated as EPRA (e.g., Priority Rank Score > or = 5). The determination of EPRA status for these 17 shops, however, was based only on the Survey Priority Rank -- without the EWG considering additional information on each shop. For example, three additional shops had a Priority Rank of 4. If other influencing factors were present (e.g., previous reported injuries), these same three shops could reasonably be "upgraded" to EPRA status. Therefore, the rate at which the Ergonomist and the Survey identified "EPRA" shops is comparable.

The criteria correlation of .5 to .7 was a broad estimate since there is no research available that has attempted to demonstrate this type of correlation. The correlation range was based on inter-rater agreement rates from previous studies [1], [2], [27]. The original estimate was also based on the assumption that the Survey was to be more comprehensive; where risk factors would be examined and rated according to job category (e.g., separate risk factor questions for Administrative, M/I, Warehouse, and Assembly work areas). Furthermore, it was predicted that the Ergonomist's risk rankings would have a higher correlation with the risk factor ratings in the Survey than with the overall Survey Priority Rank, since the Priority Rank also considered discomfort. The correlation between the body area risk rankings of the Ergonomist and the Survey ranged from -0.02 to .50. The strongest correlation's were for upper body risk factors. The Spearman Rho and weighted Kappa value for each body area comparison are presented in **Table 3.11**.

Table 3.11 Spearman Rho and Weighted Kappa Statistics for Each Body Area: Comparison Between Survey and Ergonomist Expert Results

Body Area	Rho	p. <	Kappa	95% CI
Shoulder/Neck	.46	.01	.25	.01 to .48
Hand/Wrist/Arm	.50	.004	.24	.03 to .44
Back/Torso	.03	.89	-.05	-.25 to .15
Legs/Feet	-0.02	.91	non-square	
Head/Eyes	.30	.11	non-square	

The agreement trends were consistent using both the Spearman Rho and weighted Kappa. Agreement on upper body areas was higher than the other areas. Particularly interesting was the nature of disagreements, the level at which the Survey rated the risk compared to the Ergonomist. With the exception of the legs/feet body area, the Ergonomist tended to rate the risk within the shop at a higher level than did the Survey. The frequency with which each method rated the risk higher is presented in **Table 3.12**, accompanied by the agreement frequency.

Table 3.12 Agreement Frequency by Body Zone: Comparison Between Survey and Ergonomist Expert Results

Body Area	Agreement in Ranking Ergonomist & Survey	Ergonomist Ranked Shop Higher	Survey Ranked Shop Higher
OVERALL SHOP	20	7	4
Shoulder/Neck	13	14	4
Hand/Wrist/Arm	12	16	3
Back/Torso	8	17	6
Legs/Feet	12	3	16
Head/Eyes	20	6	5

In a total of five out of the seven cases in which the Ergonomist ranked the shop higher risk than did the Survey, the low discomfort rate in the shop was a primary reason for the lower Survey ranks. Two factors explain the difference. First, the validation process required that the Ergonomist be kept blind to discomfort data. Second, in the Survey scoring process, discomfort data is weighed heavier than risk factor data. Because of these two factors, the comparison data provides a disagreement rate which is artificially high. Furthermore, the above explanation indicates that the agreement regarding ergonomic risk factors in the job (separate from discomfort) is actually greater than the reported agreement between the Ergonomist and the Survey. **Table 3.13** presents the comparison of results between the Ergonomist and the Survey.

Table 3.13 EPRA Classification Rates: Comparison Between Survey and Ergonomist Expert Results

	Ergonomist Expert EPRA	Ergonomist Expert Non-EPRA
Survey EPRA	13	4
Survey Non-EPRA	7	7

The Ergonomist's shop classifications as EPRA and Non-EPRA can be assumed to be the true classification, in spite of the limitations identified below, for the purposes of determining how well the Survey screening tool correctly classifies shops by risk status. The PV positive (predictive value of a positive score) of the Survey was calculated as 76%. This indicates that an EWG can have a relatively high degree of certainty (over 75%) that the shops they are targeting for further follow-up (classified as EPRAs) are in fact shops that need attention. If an EWG wants greater certainty that the shops classified as EPRAs by the Survey are indeed shops that need attention, the cut-off priority score could be raised from 5 to either 6 or 7. This increases the PV positive to 85%. It should be noted, however, that this also increases the likelihood of misclassifying a shop with known ergonomic risk factors as a "non-EPRA" shop.

Thirteen of the 31 shops used in this comparison study did not have the desired rate of employee participation of 80%. When these shops with lower participation rates are dropped from the comparison, PV positive is raised to 80% and PV negative is raised to 75% (from .50). Table 3.14 reports the agreement rates for shops with at least 80% response rates. The small sample size (18 remaining shops instead of original 31) suggests that these results need to be interpreted cautiously. Because of the limitations of this small sample size, the interpretation of results should remain on the findings from the full group of 31 shops. This is a conservative approach since the results from the smaller group suggest even better tool performance. Table 3.15 illustrates the effects of participation rate on EPRA agreement. The 31 shops are listed in descending order of participation rates, with the far right-hand column denoting agreement between the ergonomist and the Survey regarding EPRA status. The established target of an 80% response rate appears justified by the increasing rate of disagreements when participation drops below 80%. These results clearly indicate the importance of obtaining a high response rate and that caution must be exercised when interpreting Survey results from shops with less than an 80% participation rate. **Table 3.14** indicates that the majority of the improvement in classification agreement occurred in the reduction of false negatives. While overall agreement improved from 65% to 78%, PV negative improved from 50% to 75%. These findings also suggest that, in spite of some methodological differences in the focus of the Ergonomist and the Survey, the EPRA classification agreement between an experienced Ergonomist and the Survey is substantial. Such agreement is the desired intent of the Survey process.

Table 3.14 EPRA Classification Rates: Comparison Between Survey and Ergonomist Results Based on the 18 Shops with 80% or Higher Response Rates

	EPRA	Non-EPRA
Survey EPRA	8	2
Survey Non-EPRA	2	6

Table 3.15 EPRA Classification Rates and Shop Response Rates: Comparison Between Survey and Ergonomist

Base	Organ	Workplace	Response	Ergonomist	RF/DS	Agreement
PAFB	301 RQS	Structural Maintenance	100%	EPRA	EPRA	yes
PAFB	DECA/MSC	Commissary-Meat Cutting Room	100%	EPRA	EPRA	yes
PAFB	45 DS/SGD	Dental Lab	100%	EPRA	EPRA	yes
PAFB	45 SVS/SVRL	Library	100%	EPRA	EPRA	yes
PAFB	301 RQS/MAF	Hydraulics	100%	EPRA	Non-EPRA	
PAFB	45 MDG/SGOP	Medical Records	100%	EPRA	EPRA	yes
PAFB	45 SW/SESE	Systems Safety	100%	EPRA	EPRA	yes
PAFB	45 TRNS/LGTTS	Packing & Crating	100%	EPRA	EPRA	yes
PAFB	45 MDG/SGOPA	Appointment Desk	100%	EPRA	EPRA	yes
PAFB	45 CES/CEOHVI	Vertical Construction	100%	Non-EPRA	Non-EPRA	yes
PAFB	45 CES/CEOIUF	Liquid Fuels Maintenance	100%	Non-EPRA	Non-EPRA	yes
PAFB	45 CS/SCMMG	Radio Maintenance Work Center	100%	Non-EPRA	Non-EPRA	yes
PAFB	41 RQS/DOTL	Life Support	100%	Non-EPRA	Non-EPRA	yes
PAFB	DPS/DBO	Reproduction Shop	100%	Non-EPRA	EPRA	
CCAS	6 SWS	Administrative Assistant	100%	EPRA	Non-EPRA	
CCAS	6 SWS	Entry Controller	100%	Non-EPRA	Non-EPRA	yes
PAFB	45 CS/SCM	Cable/Telephone Maintenance	86%	Non-EPRA	Non-EPRA	yes
CCAS	6 SWS	MWOC	80%	Non-EPRA	EPRA	
PAFB	DECA	Commissary Whse.	78%	EPRA	EPRA	yes
PAFB	45 CES/CEOHH	Horizontal Construction	76%	EPRA	Non-EPRA	
PAFB	45 CES Zone 2	Facility Maint. Zone 2	75%	Non-EPRA	EPRA	

Base	Organ	Workplace	Response	Ergonomist	RF/DS	Agreement
PAFB	RAYTHEON	Shipping and Receiving	73%	EPRA	EPRA	yes
PAFB	45 MDG	Dental Treatment	72%	EPRA	EPRA	yes
PAFB	DECA/SO/PAT	Commissary	71%	EPRA	EPRA	yes
PAFB	45 SW/XP	Wing Plans	69%	EPRA	Non-EPRA	
PAFB	741 MS/MAES	Survival Equipment	67%	EPRA	EPRA	yes
CCAS	6 SWS	Administrative Assistant	66%	EPRA	Non-EPRA	
PAFB	45 TRNS/LGTTF	Air Terminal	56%	EPRA	Non-EPRA	
PAFB	741 MS/MACA	Aerospace Ground Equipment	56%	Non-EPRA	EPRA	
PAFB	45 CES/CEH	Housing Office	47%	EPRA	Non-EPRA	
CCAS	6 SWS	Security Controller	40%	Non-EPRA	Non-EPRA	yes

The results indicated that a survey methodology could provide similar screening information compared to the method of having an experienced Ergonomist visit individual shops and assess the ergonomics hazard. In most cases, the Ergonomist and the Survey agreed on the decision to recommend status as an EPRA shop. This was the primary consideration in testing the Survey tool, and the results indicate that the tool performs its intended function.

Although the Survey performed well, the contractor investigated the potential that the performance could be enhanced through changes in the scoring cut-offs. The impact of altering the Job Factor (risk factor) exposure percentages for obtaining ratings on the Survey was investigated. The back/torso area was used as the basis for testing the change, since agreement was the lowest. One shop was dropped from this step due to missing data related to raw percentages. A scatter-plot was created to compare Ergonomist ratings with tally percents. Based on the tally percent distributions, new cut-offs of 20% for Medium and 40% for High were tested. Agreement improved to 14, with the Ergonomist rating 10 jobs higher and the Survey rating six jobs higher. Spearman Rho and weighted Kappa values were both increased to .12 and .08, respectively. However, neither of these tests indicated sufficient agreement to justify concluding significant improvement. Applying the 20% and 40% cut-offs to the shoulder/neck Survey section resulted in slight, but not significant, reduction in agreement. There is no indication that altering the percent cut-offs in the Survey for determining risk exposure would result in significant improvements in the agreement between the Ergonomist and the Survey.

The agreement rates may have been higher still if the Ergonomist had not been intentionally kept blind to all aspects of survey development. The results can be summarized by considering the advantages and disadvantages of keeping the Ergonomist blind to the Survey and Priority Rank methodology. The obvious advantage was that, since the Ergonomist remained blind, the risk of biasing results to match those expected by the Survey were minimized. In addition, during the shop visit, the Ergonomist was unable to “prep” employees for how to interpret or answer the Survey questions. Employees, therefore, were able to complete the Survey without any

predisposition. The disadvantages and possible explanations for the lower than predicted agreement between the Ergonomist and the Survey are listed below:

- **Difference in judgment between average vs. worst exposures**. The Survey focused on the average exposure within a shop. Since the Ergonomist was kept blind to the Survey methodology, he may have placed more focus on the worst of the exposures observed within a shop during the visit rather than an average of all exposures - and rated the shop higher. This, in fact, was the case particularly for the back/torso body zone and for shops whose tasks were low in frequency and duration, but whose biomechanical demands (e.g., severity) were extreme. When these types of tasks were observed (and sometimes demonstrated as "representative"), the Ergonomist gave a higher rank than that which was provided by the Survey.

- **Absence of information on discomfort**. Discomfort information could not be provided to the Ergonomist without potentially biasing the ranking. Since the Ergonomist had no information on discomfort and since the Survey Priority Rank is weighted more heavily on discomfort than risk factor exposure, another source for variation is introduced.

- **Use of past reported incidents as a primary means for ranking shops**. The Ergonomist considered risk factor exposure to the same body zones as is used in the Survey. However, he also used evidence of past incidents (e.g., WMD) to establish shop rank. The Survey considers the use of past incidents in ***interpreting*** the Survey Priority Rank, not in ***establishing*** the Survey Priority Rank.

- **Low response rates from a number of shops**. Thirteen of the 31 shops had five or less respondents, with several shops having only one or two respondents. Since the Survey results are based on percentages of people exposed to risk factors and reporting discomfort, results based on small numbers of respondents are subject to large fluctuations. For example, a single response from one person could create the difference between a low and high risk shop.

- **Simplification of the Survey design**. Initial drafts of the Survey were simplified to meet the time-for-completion objectives established by the Air Force. Two significant simplifications which would be cause for re-evaluating (e.g., lowering) the original agreement estimate (.5 to .7) included:

  – eliminated assessment of risk factor exposure by work area type (e.g., Administrative, M/I, Warehouse, and Assembly) in favor of one general Job Factors section; and

  – eliminate the "weighting" of several risk factors in scoring in favor of establishing the "weight" of each risk factor as equal in order to simplify and increase the speed of the scoring process.

The Survey may function best when all of its components are used when reaching a decision on EPRA status. In addition to the Priority Rank, the following ***must*** be used when making the EPRA determination:

- influence of organizational factors;
- influence of employee perception of physical effort;
- influence of health or other conditions that may impact reported discomfort; and
- history of past reported incidents.

This reinforces the decision to place the final determination of EPRA status and strategy for intervention into the hands of the EWG supported by information provided by the Survey.

3.4 Discussion

The test/retest reproducibility of the individual questions was evaluated to determine if the modifications to the questions had altered their reproducibility from earlier studies. The Kappa values obtained on individual questions were generally equivalent indicating that the alterations to questions had minimal impact ([24], [4]). The agreement on the scale scores is also comparable to previous findings. The Kappa values ranging up to .68 for the body part scale scores are similar to the Spearman Rho scores of .69 to .82 for the repetition, force, and whole body activity scales reported by Cole [1].

This suggests that the modifications made to the questions and answers categories had a minimal impact on reproducibility. In addition, the new questions which were created specifically for the Survey (based on risk factors reported in the literature) had reproducibility rates similar to questions found in existing surveys, as did questions which were adapted from questions found in existing surveys.

The reproducibility and validity of the Survey appears stronger for upper extremity concerns (shoulder/neck and hands/wrists/arms) than for the other body areas. This needs to be taken into consideration when the EWG makes the final EPRA determination, especially when dealing with "borderline" jobs. For example, if the hand/wrist/arm score determined an Survey Priority Rank of 5, the EWG should be discouraged from excluding the shop from EPRA status based on the other considerations. If, on the other hand, the legs/feet score determined the overall Priority Rank of 4, the EWG is encouraged to carefully review the other considerations before reaching a final decision on EPRA status. Depending on the other considerations, that shop might be upgraded to EPRA status.

3.5 Conclusions

The Survey performs effectively and efficiently as an active surveillance/screening tool. The strengths of the Survey are listed below:

- The Survey is quick and easy to administer. The Survey can be administered to and completed by a group (unlimited size) of assembled employees in approximately 45 minutes.

- The Survey is quick and easy to score. In the most recent trials, scoring for a shop of 25 employees was completed by Public Health in less than 2 hours.

- Parts II (Work Content) and Parts IV (Process Improvement Opportunities) enable employees to categorize their routine types of work processes, activities, and tasks, according to standardized categories. Part IV specifically enables employees to comment directly on the tasks, tools, equipment, materials, etc. that they feel most relates to their perceived exposure to ergonomic risk factors or personal experience with discomfort or fatigue. Information from both Parts can be used by Public Health and the EWG to design efficient intervention strategies as well as communicate requests for follow-up by Bioenvironmental Engineering Services.

- Completion of the Survey within a shop provides an Ergonomic Shop Priority Rank which enables Public Health and the EWG to make an initial determination of EPRA status. The Survey Priority Rank, in combination with other considerations such as past reported WMDs, organizational factors, perceived physical effort, etc., enables the EWG to make a final determination of EPRA status based on a thoughtful interpretation of the common indications of the data. The methodology recognizes the value in achieving a balance between the Survey results, professional expertise, and shop experience.

- The numerical based Survey results can be used to prioritize EPRA-classified work areas for "task specific" analyses and/or problem-solving work. The Survey Priority Rank can be used to establish an initial priority list (e.g., Priority 1 - Shop A, Survey Priority Rank 8; Priority 2 - Shop B; Survey Priority Rank 7; and so on). The Work Content (Part III) and Process Improvement Opportunities (Part IV) sections provide information on the processes, tasks, equipment, etc. that may be the targets of initial action for follow-up.

- Results of the Survey provide an indication of and the relative importance of ergonomic, psychosocial, and individual factors that may be present in the work area. Ergonomic factors (e.g., job factors, discomfort factors) are of primary importance in determining the Survey Priority Rank of the shop. Psychosocial factors and their potential impact on the ergonomic factors can be considered by reviewing the Organizational Ratings. For example, a rating of High in the Organizational Factors section indicates that many people in the shop may experience a high level of job stress. High levels of job stress can decrease job performance and increase the experience of pain and discomfort. If the

Organizational Rating is High, it suggests that a follow-up job stress evaluation may be used as follow-up. Individual factors and their potential impact on ergonomic factors can be considered by reviewing the Contributing Factors Score. This percentage provides insight into interpreting the Discomfort Rating. For example, if the Contributing Factors score is above 20%, the Discomfort Rating could have been impacted by a high percentage of employees with conditions that increase the prevalence of WMDs.

- Data from the Survey allows calculation of employee-reported discomfort prevalence rates. Information contained in the Discomfort Factors section enables Public Health to calculate, by body zone (e.g., shoulder/neck, hands/arms/wrists, back/torso, legs/feet, and head/eyes), the percentage of employees within a shop who are experiencing or who have experienced discomfort in the year preceding their completion of the Survey. This information may also be used by Public Health to gain insight into the effectiveness of the Air Force injury and illness reporting system and determine whether or not it is likely that employees are under-reporting their musculoskeletal discomfort or symptoms of WMDs.

In addition, the Survey has similar or better reproducibility than other ergonomic screening tools reported in the literature. The Survey performs best in shops with six or more employees and results are most reliable when at least 80% employee participation is obtained. More importantly, the Survey Methodology provides the Air Force with a tool that is unique to the field of ergonomics. It is the first tool for which reproducibility has been reported to allow for the following: (1) enables a massive organization to systematically and quickly, with a minimum of resources, assess employee exposure to ergonomic factors in all types of work environments; (2) results (Survey Priority Rank) can be used to establish overall priorities for further investigation at the shop level; (3) results (Work Content and Process Improvement Opportunities) can be used to establish a plan for specific follow-up within the higher priority shops; and (4) can be used to measure the potential impact of problem-solving efforts that have been completed within a shop and for all shops throughout the organization.

Finally, the Survey Methodology provides data necessary to enable the Air Force to maximize the value of the professional expertise and experience of Public Health and members of the EWG. These two entities are charged with the final determination of EPRA status and the design of an intervention strategy to prevent WMDs among Air Force personnel.

APPENDIX E
ATTACHMENT 1

Job Requirements and Physical Demands Survey

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification

Question - 1:	I work with my hands at or above chest level.
Original Question:	Is an elbow used at or above mid-torso level?
Validity Testing Reported:	Yes
Rationale for Change:	Clarification of physical landmark.
Risk Factor:	Non-neutral position of the shoulder, static fatigue.
Reference	Bjelle, A., Hagberg, M. and Michaelsson, G. (1979). Clinical and ergonomic factors in prolonged shoulder pain among industrial workers. *Scand. J. Work Environ. and Health.* (Vol. 5, pp. 205-210).
	Keyserling, W.M., Brouwer, M., and Silverstein, B.A. (1993). The effectiveness of a joint labor-management program in controlling awkward postures of the trunk, neck and shoulders: Results of a field study. *International Journal of Industrial Ergonomics.* (Vol. 11, pp., pp. 51-65).
Potential WMD	Shoulder Bursitis, Thoracic Outlet Syndrome, Rotator Cuff Tendonitis, and Upper Back Disorders.
Question - 2:	To get to or to do my work, I must lay on my back or side and work with my arms up.
Original Question:	N/A - based on core risk factor.
Validity Testing Reported:	N/A
Rationale for Change:	New question added to reflect demands of Maintenance and Inspection work.
Risk Factor Basis:	Non-neutral position of the shoulder, static fatigue.
Reference	Bateman, J.E. (1983). Neurologic painful conditions affecting the shoulder. *Clin. Orthop. Rel. Res.* (Vol. 173., pp. 44-54).
	Chaffin, D.B. (1973). Localized muscle fatigue. Definition and measurement. *J. Occup. Med.* (Vol. 15, pp. 346-354).
Potential WMD:	Shoulder Bursitis, Thoracic Outlet Syndrome, Rotator Cuff Tendonitis, and Upper Back Disorders.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 3	I must hold or carry materials (or large stacks of files) during the course of my work.
Original Question:	N/A - based on core risk factor.
Validity Testing Reported:	N/A
Rationale for Change:	New question added to reflect work requirements.
Risk Factor Basis:	Non-neutral position of the shoulder, static fatigue.
Reference	Chaffin, D.B. (1973). Localized muscle fatigue: Definition and measurement. *J. Occup. Med*. (Vol. 15, pp. 346-354).
	Mital, A., Nicholson, A.S., and Ayoub, M.M. (1993*). A Guide to Manual Materials Handling*. London, England: Taylor & Francis.
Potential WMD:	Shoulder Bursitis, Thoracic Outlet Syndrome, Rotator Cuff Tendonitis, and Upper Back Disorders.
Question - 4:	I force or yank components or work objects in order to complete a task.
Original Question:	N/A - based on core risk factor.
Validity Testing Reported:	N/A
Rationale for Change:	New question added to reflect demands of Maintenance and Inspection work.
Risk Factor Basis:	Non-neutral position of the shoulder, high speed arm motions.
Reference	Putz-Anderson, V. (1992). *Cumulative trauma disorders: A manual for musculoskeletal diseases of the upper limb*. London, England: Taylor & Francis.
Potential WMD:	Shoulder Bursitis, Thoracic Outlet Syndrome, Rotator Cuff Tendonitis, Medial/Lateral Epicondylitis.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 5:	I reach or hold my arms in front of or behind my body (e.g., using a keyboard, filing, handling parts, performing inspection tasks, pushing or pulling carts, etc.).
Original Question:	Is repeated or sustained work performed when one arm reaches forward or to the side without support?
Validity Testing Reported:	Yes
Rationale for Change:	Clarification of risk factor (e.g., "hold" replaces "sustained work") and addition of work situation examples to provide context.
Risk Factor Basis:	Non-neutral position of the shoulder, static fatigue.
Reference	Chaffin, D.B. (1973). Localized muscle fatigue: Definition and measurement. *J. Occup. Med*. (Vol. 15, pp. 346-354).
	Corlett, E.N. (1983). Analysis and evaluation of working postures. In T.O. Kvalseth (Ed.), *Ergonomics of Workstation Design.* (pp. 12-15). London: Butterworths.
	Kemmlert, K. (1994). A Method Assigned for the Identification of Ergonomic Hazards - PLIBEL. *Scandinavian Journal of Rehabilitative Medicine. (*Vol. 26, pp. 1-21).
	Nichols, H.M. (1967). Anatomic structures of the thoracic outlet. *Clin. Orthop. Rel. Res.* (Vol. 51, pp. 17-25).
Potential WMD:	Shoulder Bursitis, Thoracic Outlet Syndrome, Rotator Cuff Tendonitis.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 6:	My neck is tipped forward or backward when I work.
Original Question:	Does your work involve that you hold your head bent forward?
Validity Testing Reported:	Yes
Rationale for Change:	Improve clarity of risk factor, add neck bent backward as another expectedly common and stressful work position for the neck.
Risk Factor Basis:	Non-neutral position of the neck, static fatigue.
Reference	Chaffin, D.B. (1973). Localized muscle fatigue: Definition and measurement. *J. Occup. Med.* (Vol. 15, pp. 346-354).
	Hagberg, M. (1984). Occupational musculoskeletal stress and disorders of the neck and shoulder: a review of possible pathophysiology. *Int. Arch. Occup. Environ. Health.* (Vol. 53, pp. 269-278).
	Keyserling, W.M., Brouwer, M., and Silverstein, B.A. (1993). The effectiveness of a joint labor-management program in controlling awkward postures of the trunk, neck and shoulders: Results of a field study. *Int. J. Ind. Ergon.* (Vol. 11, pp. 51-61).
	Van Wely, P. (1970). Design and Disease. *Appl. Ergon.* (Vol., No. 5, pp. 262-269).
	Wiktorin, C., et al. (1993). Validity of self--reported exposures to work postures and manual materials handling. *Scand. J. Work Environ Health*, (Vol. 19, pp. 208-214).
Potential WMD:	Disc Degeneration in Cervical Spine, Tendonitis.
Question - 7:	I cradle a phone or other device between my neck and shoulder.
Original Question:	N/A - based on core risk factor.
Validity Testing Reported:	N/A
Rationale for Change:	New question added to reflect work situations found in administrative and M&I tasks.
Risk Factor:	Non-neutral position of the shoulder/neck, neurovascular compression, static fatigue.
Reference	Chaffin, D.B. (1973). Localized muscle fatigue: Definition and measurement. *J. Occup. Med.* (Vol. 15, pp. 346-354).
	Dale, W.A. (1982). Thoracic outlet compression syndrome. *Arch. Surg*. (Vol. 117, pp. 1437-1445).
	Tyson, R.R., and Kaplan, G.F. (1975). Modern concepts of diagnosis and treatment of the thoracic outlet syndrome. *Orthop. Clinics of North America* (Vol. 6, pp. 507-519).
Potential WMD	Thoracic Outlet Syndrome, Rotator Cuff Tendonitis.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 8:	My wrists are bent (up, down, to the thumb or little finger side) while I work.
Original Question:	Can the job be done without bending the wrist?
Validity Testing Reported:	Yes
Rationale for Change:	Clarification of risk factor, direct evaluation of required wrist posture rather than evaluation of task and possibility of change, example of bent wrist postures.
Risk Factor:	Non-neutral hand/wrist positions.
Reference	Lifshitz, Y., and Armstrong, T. (1986). A Design Checklist for Control and Prediction of Cumulative Trauma Disorder in Intensive Manual Jobs. In *Proceedings of the Human Factors Society 30th Annual Meeting.* (pp. 945-950).
Potential WMD	Hand/wrist disorders: Tendonitis, Carpal Tunnel Syndrome.
Question - 9:	I apply pressure or hold an item/material/tool (e.g., screw driver, spray gun, mouse, etc.) in my hand for longer than 10 seconds at a time.
Original Question:	Is the tool continually held in the hand?
Validity Testing Reported:	No
Rationale for Change:	Applicability of question expanded to all tasks that may require static work in the hands rather than just those tasks which involve tool use, example work situations added to provide context.
Risk Factor:	Prolonged force application.
Reference	Reynolds et al (1994). A field methodology for the control of musculoskeletal injuries. *Applied Ergonomics*. (Vol. 25, No. 1, pp. 3-16).
Potential WMD	Tendonitis.
Question - 10:	My work requires me to use my hands in a way that is similar to wringing out clothes.
Original Question:	Can the job be done without "clothes wringing" motion?
Validity Testing Reported:	Yes
Rationale for Change:	Clarification of risk factor, direct evaluation of motion rather than evaluation of task and possibility of change.
Risk Factor:	Non-neutral wrist/arm/elbow positions.
Reference	Lifshitz, Y., and Armstrong, T. (1986). A Design Checklist for Control and Prediction of Cumulative Trauma Disorder in Intensive Manual Jobs. In *Proceedings of the Human Factors Society 30th Annual Meeting* (pp. 945-950).
Potential WMD	Tendonitis, Carpal Tunnel Syndrome, Medial/Lateral Epicondylitis.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 11:	I perform a series of repetitive tasks or movements during the normal course of my work (e.g., using a keyboard, tightening fasteners, cutting meat, etc.).
Original Question:	N/A - based on core risk factor.
Validity Testing Reported:	N/A
Rationale for Change:	New question added to introduce the "repetition" factor, work situation examples provided for context.
Risk Factor:	Frequency of similar motions.
Reference	Kilbom, A. (1994*). Int. J. Ind. Ergon.* (Vol. 14, pp. 59-86).
	Kuorinka, I., and Koshinen, P. (1979). Occupational rheumatic diseases and upper limb strain in manual jobs in a light mechanical industry. *Scand. J. Work Environ. Health* (Vol. 5, No. 3, pp. 39-47).
Potential WMD	Hand/wrist/shoulder/elbow disorders: Carpal Tunnel Syndrome, Tendonitis, Epicondylitis, ganglion cysts.
Question - 12:	The work surface (e.g., desk, bench, etc.) or tool(s) that I use presses into my palm(s), wrist(s), or against the sides of my fingers leaving red marks on or beneath the skin.
Original Question:	Do the hands/wrists/arms come in contact with any sharp, or non-rounded edges on the table/machinery?
Validity Testing Reported:	No
Rationale for Change:	First person verbiage, work situation examples added to provide context (especially for administrative work), "sharp" term discarded to keep focus on instances where the work surface puts pressure on the body region.
Risk Factor:	External trauma/Ischemia.
Reference	Reynolds, et al. (1994). A field methodology for the control of musculoskeletal injuries. *Applied Ergonomics*. (Vol. 25, No. 1, pp. 3-16).
	Putz-Anderson, V. (1992). *Cumulative trauma disorders: A manual for musculoskeletal diseases of the upper limb*. London, England: Taylor & Francis.
Potential WMD	Neural entrapment.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 13:	I use my hand/palm like a hammer to do certain aspects of my work.
Original Question:	Is the palm or base of the hand used as a striking tool (like a hammer)?
Validity Testing Reported:	Yes
Rationale for Change:	Clarification of risk factor.
Risk Factor:	High force projection and non-neutral hand/wrist positions.
Reference	Keyserling, W.M., Brouwer, M., and Silverstein, B.A. (1993). The effectiveness of a joint labor-management program in controlling awkward postures of the trunk, neck and shoulders: Results of a field study. *Int. J. Ind. Ergon.* (Vol. 11, pp. 51-61).
	Putz-Anderson, V. (1992). *Cumulative trauma disorders: A manual for musculoskeletal diseases of the upper limb.* London, England: Taylor & Francis.
Potential WMD	Carpal Tunnel Syndrome, Tendonitis.
Question - 14:	My hands and fingers are cold when I work.
Original Question:	N/A - based on core risk factor.
Validity Testing Reported:	N/A
Rationale for Change:	New question added to reflect the effect of temperature extremes, especially cold, on the hand/wrist/arm.
Risk Factor:	Cold temperature.
Reference	Heus, R., Daanen, H.A.M., and Haventh, G. (1995). Physiological criteria for functioning of hands in the cold. *Appl. Ergon.* (Vol. 26, No. 1, pp. 5-13).
	Holmer, I. (1994) Cold Stress - Part I: Guide for the Practitioner. *Int. J. Ind. Ergon.* (Vol. 14, pp. 139-149).
Potential WMD	Carpal Tunnel Syndrome, HAVS.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 15:	I work at a fast pace to keep up with a machine production quota or performance incentive.
Original Question:	N/A - based on core risk factor.
Validity Testing Reported:	N/A
Rationale for Change:	Added new question to reflect insufficient recovery time risk factor.
Risk Factor:	Incentive based production, i.e., lack of time for rest/repair.
Reference	Feldman, R.G., Goldman, R., and Keyserling, W.M. (1983). Peripheral nerve entrapment syndromes and ergonomic factors. *Am. J. Ind. Med*. (Vol. 4, pp. 661-681).
	Ohara, H., Aoyama, H., Itani, T., Nakagiri, S., and Wake, K. (1976). Occupational health hazards resulting from elevated work rate situations. *J. Human Ergon*. (Vol. 5, pp. 173-182).
	Silverstein. B.A., Fine, L.J., and Armstrong, T.J. (1987). Occupational factors and Carpal Tunnel Syndrome. *Am. J. Ind. Med*. (Vol. 11, pp. 343-358).
	Silverstein, B.A., Fine, L.J., and Armstrong, T.J. (1986). Hand/ wrist cumulative trauma disorders in industry. *Br. J. of Ind. Med*. (Vol. 43, pp. 779-784).
	Smith, M.J., Carayon, P., Sanders, K.J., Lim, S.Y., and LeGrande, D. (1992). Employee stress and health complaints in jobs with and without electronic performance monitoring. *Appl. Ergon.* (Vol. 23, No. 1, pp. 17-27).
Potential WMD	Hand/wrist/elbow disorders: De Quervain's, Tendonitis, ganglion cyst, Carpal Tunnel Syndrome, Medial/Lateral Epicondylitis.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 16:	The tool(s) that I use vibrate and/or jerk in my hand(s) and arm(s).
Original Question:	Does the tool or object jerk the hand?
Validity Testing Reported:	Yes
Rationale for Change:	Combined vibration and "torque" (jerk) risk factors to minimize number of questions.
Risk Factor:	Vibration and the application of excessive forces.
Reference	Keyserling, W.M., Brouwer, M., and Silverstein, B.A. (1993). The effectiveness of a joint labor-management program in controlling awkward postures of the trunk, neck and shoulders: Results of a field study. *Int. J. Ind. Ergon.* (Vol. 11, pp. 51-61).
	Kihlberg, S. (1995). Biodynamic response of the hand-arm system to vibration from an impact hammer and grinder. *Int. J. Ind. Ergon.* (Vol. 16, pp. 1-8).
Potential WMD	Hand/wrist/elbow disorders: HAVS, Carpal Tunnel Syndrome, Medial/Lateral Epicondylitis.
Question - 17:	My work requires that I repeatedly throw or toss items.
Original Question:	N/A - based on core risk factor.
Validity Testing Reported:	N/A
Rationale for Change:	New question added to reflect demands of Air Force work.
Risk Factor:	High speed arm motions.
Reference	Delisie, A., Gagnon, M. (1995). Segmental dynamic analysis when throwing loads. *Int. J. Ind. Ergon.* (Vol. 16, pp. 9-21).
Potential WMD	Shoulder/arm/elbow disorders: Medial/Lateral Epicondylitis, Rotator Cuff Tendonitis.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 18:	My work requires me to twist my forearms, such as turning a screwdriver.
Original Question:	Is repeated work, with forearms and hand, performed with twisting movements?
Validity Testing Reported:	Yes
Rationale for Change:	Clarification of risk factor, increased emphasis on the twisting motion, example provided for context.
Risk Factor:	Non-neutral wrist/forearms and stressful wrist motions.
Reference	Kemmlert, K. (1994). A Method Assigned for the Identification of Ergonomic Hazards - PLIBEL. *Scandinavian Journal of Rehabilitative Medicine (*Vol. 26, pp. 1-21).
	Armstrong, T., Werner, R., Waring, W., and Foulke, J. (1986). *Intra-Carpal Canal Pressure in Selected Hand Tasks*. The University of Michigan.
	Chaffin, D.B. (1973). Localized muscle fatigue: Definition and measurement. *J. Occup. Med.* (Vol. 15, pp. 346-354).
	Putz-Anderson, V. (1992). *Cumulative trauma disorders: A manual for musculoskeletal diseases of the upper limb*. London, England: Taylor & Francis.
Potential WMD	Hand/wrist disorders: Carpal Tunnel Syndrome, Tendonitis, De Quervain's Syndrome. Shoulder/elbow disorders: Medial/Lateral Epicondylitis.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 19:	I wear gloves that are bulky, or reduce my ability to grip.
Original Question:	Do the gloves hinder gripping?
Validity Testing Reported:	Yes
Rationale for Change:	Clarification of risk factor (e.g., "reduce my ability" replaces "hinder," question reworded to reflect that some employees do not wear gloves.
Risk Factor:	Increased grip force.
Reference	Batra, S., Wang, M.J., and Bishu, R.R. (1994). Glove attributes: Can they predict performance? *Int. J. Ind. Ergon*. (Vol. 14, pp. 201-209).
	Keyserling, W.M., Brouwer, M., and Silverstein, B.A. (1993). The effectiveness of a joint labor-management program in controlling awkward postures of the trunk, neck and shoulders: Results of a field study. *Int. J. Ind. Ergon* (Vol. 11, pp. 51-61).
	Nelson, J.B., and Mital A. (1995). An Ergonomical Evaluation of the Primary Hand Flexibility and Capability Changes with Increases in Examination/Surgical Glove Thickness. *Ergonomics* (Vol. 38, No. 4).
	Bishu, R.R., and Klute, G. (1995). The effects of external vehicular activity (EVA) gloves on human performance, *Int. J. Ind. Ergon*. (Vol. 16, pp. 165-174).
Potential WMD	Hand/wrist disorders: Carpal Tunnel Syndrome, Tendonitis, De Quervain's Syndrome. Shoulder/elbow disorders: Medial/Lateral Epicondylitis.
Question - 20:	I apply pressure with my hands similar to the way people use their hands to open a new bottle of soda.
Original Question:	Estimate the average amount of time per day that requires as much force as: unscrewing a bottle cap on a new bottle or container of pop (a bottle or container that has never been opened).
Validity Testing Reported:	Yes
Rationale for Change:	Simplification of question, used term "apply pressure" instead of "force" as a more direct statement of the risk factor.
Risk Factor:	High force pinch grips.
Reference	Cole, L.L. (1995). *Construction and Validation of a Musculoskeletal Risk Questionnaire.* Dissertation.
Potential WMD	Hand/wrist disorders: Carpal Tunnel Syndrome, Tendonitis, De Quervain's Syndrome.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 21:	I grip work objects or tools as if I am gripping tightly onto a pencil.
Original Question:	Is a pinch grip used?
Validity Testing Reported:	Yes
Rationale for Change:	More direct statement of the risk factor, example of pinch grip provided for those individuals who have never heard the term, added a "force" component to the question to distinguish those individuals who may be applying significant finger tip force (rather than just using the finger tips).
Risk Factor:	High force pinch grips.
Reference	Dempsey, P.G., and Ayoub, M.M. (1996). The influence of gender, grasp type, pinch width and wrist position on sustained pinch strength. *Ind. J. Ind. Ergon*. (Vol. 17, pp. 259-273).
	Keyserling, W.M., Brouwer, M., and Silverstein, B.A. (1993). The effectiveness of a joint labor-management program in controlling awkward postures of the trunk, neck and shoulders: Results of a field study. *Int. J. Ind. Ergon* (Vol. 11, pp. 51-61).
	Silverstein. B.A., Fine, L.J., and Armstrong, T.J. (1987). Occupational factors and Carpal Tunnel Syndrome. *Am. J. Ind. Med.* (Vol. 11, pp. 343-358).
Potential WMD	Hand/wrist disorders: Carpal Tunnel Syndrome, Tendonitis, De Quervain's Syndrome.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 22:	When I lift, move components, or do other aspects of my work, my hands are lower than my knees.
Original Question:	Are loads lifted manually? Notice factors of importance as handling below knee height.
Validity Testing Reported:	Yes
Rationale for Change:	Clarification of risk factor, expanded applicability of risk factor (stressful posture) to work which involves handling activities in addition to lifting.
Risk Factor:	Asymmetrical lifting, twisting.
Reference	Reynolds, J.L., Drury, C.G., and Broderick, R.L. (1994). A field methodology for the control of musculoskeletal injuries. *Appl. Ergon*. (Vol. 25, No. 1, pp. 3-16).
	Kemmlert, K. (1994). A Method Assigned for the Identification of Ergonomic Hazards - PLIBEL. *Scandinavian Journal of Rehabilitative Medicine* (Vol. 26, pp. 1-21).
	Van Wely, P. (1970). Design and disease. *Appl. Ergon.* (Vol. 1, pp. 262-269).
Potential WMD	Lower/upper back disorders.
Question - 23:	I lean forward continually when I work (e.g., when sitting, when standing, when pushing carts, etc.).
Original Question:	Is repeated or sustained work performed when the back is flexed forward?
Validity Testing Reported:	Yes
Rationale for Change:	Clarification of risk factor (e.g., "lean forward" replaces "when the back is flexed"), question simplified to focus on working in an awkward static posture.
Risk Factor:	
Reference	Chaffin, D.B., Andersson, G.B.J. (1984). *Occupational Biomechanics* (pp. 304). John Wiley & Sons, New York.
	Kemmlert, K. (1994). A Method Assigned for the Identification of Ergonomic Hazards - PLIBEL. *Scandinavian Journal of Rehabilitative Medicine* (Vol. 26, pp. 1-21).
Potential WMD	Lower/upper back disorders.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 24:	The personal protective equipment or clothing that I wear limits or restricts my movement.
Original Question:	N/A
Validity Testing Reported:	N/A
Rationale for Change:	New question to reflect the additional demands that may be placed on the body (e.g., force) due to PPE.
Risk Factor:	Force application, awkward/non-neutral body segment positions.
Reference	Akbarkhanzadeh, F., Bisesi, M.S., Rivas, R.D. (1995). Comfort of personal protective equipment. *Appl. Ergon*. (Vol. 26, No. 3, pp. 195-198).
	Dunbar, E. (1993). The role of psychological stress and prior experience in the use of personal protective equipment. *J. Safety Res*. (Vol. 24, No. 3, pp. 181-187).
Potential WMD	Lower/upper back disorders, Tendonitis.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 25:	I perform a series of repetitive tasks or back movements during the course of my work (e.g., bending forward, backward, or to the side, or twisting).
Original Question:	Is repeated or sustained work performed when the back is flexed forward?
Validity Testing Reported:	Yes
Rationale for Change:	Simplified the question to place focus on repeated stressful movements of the back, eliminated reference to sustained work (now in Question 23), described the types of back movements to be considered.
Risk Factor:	Asymmetrical lifting, twisting, non-neutral back positions.
Reference	Kemmlert, K. (1994). A Method Assigned for the Identification of Ergonomic Hazards - PLIBEL. *Scandinavian Journal of Rehabilitative Medicine* (Vol. 26, pp. 1-21).
	Fard, H., and Mital, A. (1993). A psychophysical study of high and very high frequency manual materials handling - Part I: Lifting and Lowering. *Int. J. Ind. Ergon.* (Vol. 12, pp. 127-141).
	Fard, H., and Mital, A. (1993). A psychophysical study of high and very high frequency manual materials handling - Part II: Carrying and Turning. *Int. J. Ind. Ergon.* (Vol. 12, pp. 143-156).
	Kumar, S. (1995) Development of predictive equations for lifting strength. *Appl. Ergon.* (Vol. 26, No. 5, pp. 327-341).
	Mital, A., Foononifard, H., and Brown, M.L. (1994, June). Physical fatigue in high and very high frequency manual handling - perceived exertion and physiological indicators. *Human Factors* (Vol. 36, No. 2, pp. 219-231).
	Thomas, R.G., van Baar, C.E., and van der Stee, M.J. (1995). Baggage handling: Posture and the design of conveyors. *Appl. Ergon.* (Vol. 26, No. 2, pp. 123-127).
Potential WMD	Lower/upper back disorders, Tendonitis.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 26:	When I lift, my body is twisted and/or I lift quickly.
Original Question:	Does the task require you to twist or bend while lifting/lowering or pushing/pulling?
Validity Testing Reported:	No
Rationale for Change:	Simplified question to eliminate reference to bending which is included in other questions, combined twisting with speed of lift (e.g., acceleration).
Risk Factor:	Asymmetrical lifting, twisting, high speed motions.
Reference	Fard, H., and Mital, A. (1993). A psychophysical study of high and very high frequency manual materials handling - Part I: Lifting and Lowering. *Int. J. Ind. Ergon.* (Vol. 12, pp. 127-141).
	Fard, H., and Mital, A. (1993). A psychophysical study of high and very high frequency manual materials handling - Part II: Carrying and Turning. *Int. J. Ind. Ergon.* (Vol. 12, pp. 143-156).
	Kumar, S. (1995). Development of predictive equations for lifting strength. *Appl. Ergon.* (Vol. 26, No. 5, pp. 327-341).
	Mital, A., Foononifard, H., and Brown, M.L. (1994, June). Physical fatigue in high and very high frequency manual handling - perceived exertion and physiological indicators. *Human Factors* (Vol. 36, No. 2, pp. 219-231).
	Thomas, R.G., van Baar, C.E., and van der Stee, M.J. (1995). Baggage handling: Posture and the design of conveyors. *Appl. Ergon.* (Vol. 26, No. 2, pp. 123-127).
Potential WMD	Lower/upper back disorders, Tendonitis.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 27:	I can feel vibration through the surface that I stand on or through my seat.
Original Question:	Do you work on jolting surfaces e.g., vibrating floor, ship floor, vehicle seat?
Validity Testing Reported:	Yes
Rationale for Change:	Clarification of risk factor, reworded to focus on what the employee experiences rather than an aspect of the workplace.
Risk Factor:	Vibration, unsupported seating.
Reference	Wiktorin, C., Karlqvist, L., et al. (1993). Validity of self-reported exposures to work postures and manual materials handling. *Scand. J. Work Environ. Health* (Vol. 19, pp. 208-214).
	Chaffin, D.B., Andersson, G.B.J. (1984). Occupational Biomechanics (pp. 304). New York: John Wiley & Sons.
	Mattila, M., Karwowski, W., and Vilkko, M. (1993, December). *Analysis of working postures in hammering tasks on building construction sites using the computerized OWAS method.* (Vol. 24, No. 6). University of Louisville and Tampere University of Technology, Finland.
Potential WMD	Lower back disorders.
Question - 28:	I lift and/or carry items with one hand.
Original Question:	N/A - based on core risk factor.
Validity Testing Reported:	N/A
Rationale for Change:	New question added to reflect asymmetric loading of the spine which occurs in a one handed lift/carry.
Risk Factor:	Manual materials handling of heavy loads.
Reference	Mital, A., and Asfour, S.S. (1983). Maximum frequencies acceptable to males for one-handed lifting in the sagital plane. *Human Factors* (Vol. 25, No. 5, pp. 563-571).
	Mital, A., Nicholson, A.S., and Ayoub, M.M. (1993). *A Guide to Manual Materials Handling*. London: Taylor & Francis.
Potential WMD	Lower/upper back disorders, Tendonitis.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 29:	I lift or handle bulky items.
Original Question:	N/A - based on core risk factor.
Validity Testing Reported:	N/A
Rationale for Change:	New question added to reflect Air Force work situations involving large parts (with or without use of a hoist).
Risk Factor:	Manual materials handling of heavy loads.
Reference	Garg, A., Owen, B., (1994). Prevention of back injuries in healthcare workers. *Int. J. Ind. Ergon.* (Vol. 14, pp. 315-331).
	Mital, A., Nicholson, A.S., Ayoub, M.M. (1993). *A Guide to Manual Materials Handling.* London: Taylor & Francis.
Potential WMD	Lower/upper back disorders, Tendonitis.
Question - 30:	I lift materials that weigh more than 25 pounds.
Original Question:	N/A
Validity Testing Reported:	N/A
Rationale for Change:	Added new question to identify lifting situations that may be present in administrative areas (when sitting, standing, etc.).
Risk Factor:	Manual materials handling of heavy loads.
Reference	Mital, A., and Manivasagan, I. (1983). Maximum acceptable weight of lift as a function of material density, center of gravity location, hand preference, and frequency. *Human Factors* (Vol. 25, No. 1, pp. 33-42).
	Mital, A., Nicholson, A.S., and Ayoub, M.M. (1993). *A Guide to Manual Materials Handling*. London: Taylor & Francis.
Potential WMD	Lower/upper back disorders, Tendonitis.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 31:	My work requires that I kneel or squat.
Original Question:	Does your work involve that you kneel or squat?
Validity Testing Reported:	Yes
Rationale for Change:	Clarification of risk factor, first person verbiage.
Risk Factor:	Prolonged force application.
Reference	Wiktorian, et al. (1993). Validity of self-reported exposures to work postures and manual materials handling. *Scand. J. Work Environ Health* (Vol. 19, pp. 208-214).
	Mattila, M., Karwowski, W., and Vilkko, M. (1993, December). *Analysis of working postures in hammering tasks on building construction sites using the computerized OWAS method* (Vol. 24, No. 6). University of Souisville and Tampere University of Technology, Finland.
	OSHA Draft Ergonomic Protection Standard (included in list of signal risk factors).
Potential WMD	Bursitis of the knee.
Question - 32:	I must constantly move or apply pressure with one or both feet (e.g., using foot pedals, driving, etc.).
Original Question:	Is fatiguing foot pedal work performed?
Validity Testing Reported:	Yes
Rationale for Change:	The question was revised to provide a description of fatiguing work to eliminate the need for the employee to make a fatigue judgment, clarification of risk factor.
Risk Factor:	Static fatigue-lower limbs.
Reference	Kemmlert, K. (1994). A Method Assigned for the Identification of Ergonomic Hazards - PLIBEL. *Scand. J. of Rehabilitative Medicine* (Vol. 26, pp. 1-21).
Potential WMD	Lower back disorders, Varicose veins.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 33:	When I'm sitting, I cannot rest both feet flat on the floor.
Original Question:	Are the foot/legs unsupported or your thighs sloping down in the front (there is no footrest or it is not able to be used)?
Validity Testing Reported:	No
Rationale for Change:	Clarification of risk factor (when I'm sitting), simplification of question.
Risk Factor:	Unsupported lumbar region, external trauma to back of legs.
Reference	van Wely P. (1970). Design and disease. *Appl. Ergon*. (Vol. 1, pp. 262-269).
	Reynolds, J.L., Drury, D.G., and Broderick, R.L. (1994). A field methodology for the control of musculoskeletal injuries. *Applied Ergonomics* (Vol. 25, No. 1, pp. 3-16).
Potential WMD	Lower back disorders.
Question - 34:	I stand on hard surfaces.
Original Question:	Is the standing surface hard and unsupported (no mat)?
Validity Testing Reported:	No
Rationale for Change:	Clarification of risk factor, removed reference to "no mat" since floor does not necessarily have to be equipped with a mat to be an acceptable surface.
Risk Factor:	Static fatigue.
Reference	Konz, S. (1994). *Ergonomics* (Volume 37, Number 4, pp. 677).
	Reynolds, J.L., Drury, D.G., and Broderick, R.L. (1994). A field methodology for the control of musculoskeletal injuries. *Applied Ergonomics* (Vol. 25, No. 1, pp. 3-16).
	Ryan, G.A. (1989). Musculoskeletal symptoms in supermarket workers. *Ergonomics* (Vol. 32, No. 4, pp. 359-371).
Potential WMD	Varicose veins, Plantar Fascitis, Lower back disorders.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 35:	I can see glare on my computer screen or work surface.
Original Question:	Is there glare from surface reflections or other light sources which affects your ability to see your work?
Validity Testing Reported:	No.
Rationale for Change:	Clarification of risk factor, simplification of question.
Risk Factor:	Excessive glare.
Reference	Reynolds, J.L., Drury, D.G., and Broderick, R.L. (1994). A field methodology for the control of musculoskeletal injuries. *Applied Ergonomics* (Vol. 25, No. 1, pp. 3-16).
	American National Standards Institute (ANSI)/Human Factors Society Standard 100 (1988). *Human Factors Engineering of Visual Display Terminal Workstations* (pp. 11).
	Canadian Standards Association (1989). *Office Ergonomics: A National Standard of Canada* (pp. 56).
Potential WMD	Eye fatigue.
Question - 36:	It is difficult to hear a person on the phone or to concentrate because of other activity, voices, or noise in/near my work area.
Original Question:	Are there noises or sounds that distract you from your job?
Validity Testing Reported:	No
Rationale for Change:	Provided examples of "being distracted" to provide context for the question, placed focus on being distracted rather than on noise.
Risk Factor:	Lapses in concentration.
Reference	Kjellberg, A., and Landstrom, U. (1994). Noise in the office: Part I - Guidelines for the practitioner. *Int. J. Ind. Ergon.* (Vol. 14, pp. 87-91).
	Steelcase "Healthy Office."
	Kjellberg, A., and Landstrom, U. (1994). Noise in the office: Part II - The scientific basis (knowledge base) for the guide. *Int. J. Ind. Ergon.* (Vol. 14, pp. 93-118).
Potential WMD	N/A

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Question - 37:	I must look at the monitor screen constantly so that I do not miss important information (radar scope).
Original Question:	Are there high demands on visual capacity?
Validity Testing Reported:	Yes
Rationale for Change:	Clarification of risk factor, eliminated the need for the employee to decide what "high" is, provided an example of a job characteristic (e.g., look at the screen constantly) which suggests high demands on visual capacity.
Risk Factor:	Vigilance tasks.
Reference	Bergqvist, U. (1995). Video Display Terminal work - A perspective on long term changes. *Int. J. Ind. Ergon.* (Vol. 16, pp. 201-209).
	Kemmlert, K. (1994). A Method Assigned for the Identification of Ergonomic Hazards - PLIBEL. *Scand. J. of Rehabilitative Medicine* (Vol. 26, pp. 1-21).
Potential WMD	Eye fatigue, head/neck disorders.
Question - 38:	It is difficult to see what I am working with (monitor, paper, parts, etc.).
Original Question:	Is the total lighting level inadequate at your work area?
Validity Testing Reported:	No.
Rationale for Change:	Clarification of risk factor, eliminated the need for the employee to decide what is adequate.
Risk Factor:	Poor illumination.
Reference	Reynolds, J.L., Drury, D.G., and Broderick, R.L. (1994). A field methodology for the control of musculoskeletal injuries. *Applied Ergonomics* (Vol. 25, No. 1, pp. 3-16).
	American National Standards Institute (ANSI)/Human Factors Society Standard 100 (1988). *Human Factors Engineering of Visual Display Terminal Workstations* (pp. 11).
	Canadian Standards Association (1989). *Office Ergonomics: A National Standard of Canada* (pp. 56).
Potential WMD	Eye fatigue, head/neck disorders.

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Questions 39:	I often feel unclear on what the scope and responsibilities of my job are.
Original Question:	Being unclear on just what the scope and responsibilities of your job are.
Validity Testing Reported:	Yes
Rationale for Change:	Better fit with rest of Survey - changed sentence structure to first person.
Risk Factor:	Psychosocial Stressor.
Reference	Kahn, R. L., Wolfe, D. M., Quinn, R. P., Snoek, J. D. & Rosenthal, R. A. (1964). Organizational stress: studies in role conflict and ambiguity. New York. John Wiley and Sons, Inc.
Potential WMD	N/A
Questions 40:	I often feel that I have too heavy of workload, one that I could not possibly finish during an ordinary workday.
Original Question:	Feeling that you have too heavy a work load, one that you can't possibly finish during an ordinary workday.
Validity Testing Reported:	Yes
Rationale for Change:	Better fit with rest of Survey - changed sentence structure to first person.
Risk Factor:	Psychosocial Stressor.
Reference	Kahn, R. L., Wolfe, D. M., Quinn, R. P., Snoek, J. D. & Rosenthal, R. A. (1964). Organizational stress: studies in role conflict and ambiguity. New York. John Wiley and Sons, Inc.
Potential WMD	N/A

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Questions 41:	I often feel that I will not be able to satisfy the conflicting demands of various people around me.
Original Question:	Thinking that you'll not be able to satisfy the conflicting demands of various people over you.
Validity Testing Reported:	Yes
Rationale for Change:	Better fit with rest of Survey - changed sentence structure to first person.
Risk Factor:	Psychosocial Stressor.
Reference	Kahn, R. L., Wolfe, D. M., Quinn, R. P., Snoek, J. D. & Rosenthal, R. A. (1964). Organizational stress: studies in role conflict and ambiguity. New York. John Wiley and Sons, Inc.
Potnetial WMD	N/A
Questions 42:	I often find myself unable to get information needed to carry out my job.
Original Question:	The fact that you can't get information needed to carry out your job.
Validity Testing Reported:	Yes
Rationale for Change:	Better fit with rest of Survey - changed sentence structure to first person.
Risk Factor:	Psychosocial Stressor.
Reference	Kahn, R. L., Wolfe, D. M., Quinn, R. P., Snoek, J. D. & Rosenthal, R. A. (1964). Organizational stress: studies in role conflict and ambiguity. New York. John Wiley and Sons, Inc.
Potential WMD	N/A

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Questions 43:	I often do not know what my supervisor thinks of me, how he/she evaluates my performance.
Original Question:	Not knowing what your superviosr thinnks of you, how he evaluates your performance.
Validity Testing Reported:	Yes
Rationale for Change:	Better fit with rest of Survey - changed sentence structure to first person.
Risk Factor:	Psychosocial Stressor.
Reference	Kahn, R. L., Wolfe, D. M., Quinn, R. P., Snoek, J. D. & Rosenthal, R. A. (1964). Organizational stress: studies in role conflict and ambiguity. New York. John Wiley and Sons, Inc.
Potential WMD	N/A
Questions 44:	I often think that the amount of work I have to do may interfere with how well it's done.
Original Question:	Thinking that the amount of work you have to do may interfere with how well it gets done.
Validity Testing Reported:	Yes
Rationale for Change:	Better fit with the rest of the Survey - changed sentence structure to first person.
Risk Factor:	Psychosocial Stressor.
Reference	Kahn, R. L., Wolfe, D. M., Quinn, R. P., Snoek, J. D. & Rosenthal, R. A. (1964). Organizational stress: studies in role conflict and ambiguity. New York. John Wiley and Sons, Inc.
Potential WMD	N/A

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Questions 45:	How would you describe the physical effort required of you job?
Original Question:	Same
Validity Testing Reported:	Yes
Rationale for Change:	N/A
Risk Factor:	Whole body exertion, fatigue.
Reference	Borg, G. (1970). Perceived exertion as an indicator of somatic stress. Scandanavian Journal of Rehab. Medicine (vol 2, pp. 92-98).
Potential WMD	N/A
Questions 46, 49, 52, 55, 58:	In the past 12 months have you experienced any discomfort fatigue, numbness or pain that relates to your job?
Original Question:	Have you at any time during the last 12 months had trouble (such as ache, pain, discomfort, numbness) in:
Validity Testing Reported:	Yes
Rationale for Change:	Increase focus on work related discomfort.
Risk Factor:	N/A
Reference	Dickinson, C. E., Campion, K., Foster, A. F., Newman, S. J., O'Rourke, A. M. T., & Thomas, P. G. (1992). Questionnaire development: an examination of the Nordic Musculoskeletal Questionnaire. Applied Ergonomics (vol 23, No 3, pp 197-201).
Potential WMD	N/A
Questions 47, 50, 53, 56, 59:	How often do you experience discomfort, numbness or pain in this region of the body?
Original Question:	During the last year , how may different times have you had this problem?
Validity Testing Reported:	No
Rationale for Change:	Improve clarity, question was skipped if no discomfort was experienced during the last year.
Risk Factor:	N/A
Reference	ANSI Z-365 (1993, June 4). Sample surveillance tools.
Potential WMD	N/A

Job Factor Questions, Research Basis for Questions and References, and Rationale for Question Modification (Contd.)

Questions 48, 51, 54, 57, 60:	On average, how severe is the discomfort, fatigue, numbness, or pain in this region of the body?
Original Question:	According to the scale of 0-5 at the right, how would you rate this problem right now?
Validity Testing Reported:	No
Rationale for Change:	Provided descriptor in answer to enhace clarity, provide focus on routine exposure (average) as compared to momentary exposure.
Risk Factor:	N/A
Reference	ANSI Z-365 (1993, June 4). Sample surveillance tools.
Potential WMD	N/A

APPENDIX E
ATTACHMENT 2

Job Requirements and Physical Demands Survey

Statistical Analysis Summaries (SAS®)

Agreements (N=40)		
	Yes	**No**
Shoulder/Neck	5	27
Hand/Wrist	8	27
Back/Torso	1	35
Legs/Feet	13	19
Head/Eyes	6	26
Shoulder	8	25
Wrist	8	27
Back	3	30
Legs	1	37
Hand	6	28

Agreements (N=40)			
	0-2 Hours	**2-4 Hours**	**4-8 Hours**
Question 1	24	2	4
Question 2	40	0	0
Question 3	35	0	0
Question 4	35	0	0
Question 5	13	5	10
Question 6	12	4	4
Question 7	33	1	0
Question 8	17	3	5
Question 9	19	4	9
Question 10	30	1	0
Question 11	9	8	11
Question 12	30	0	2
Question 13	37	0	0
Question 14	34	0	0
Question 15	27	1	4
Question 16	26	5	1
Question 17	39	0	0
Question 18	30	3	1
Question 19	37	2	0
Question 20	38	0	0
Question 21	25	2	4
Question 22	40	0	0
Question 23	18	3	7
Question 24	36	1	0
Question 25	29	2	0
Question 26	39	0	0
Question 27	38	2	0
Question 28	39	2	0
Question 29	37	0	0
Question 30	36	1	0
Question 31	35	3	0
Question 32	32	2	1
Question 33	31	2	0
Question 34	23	3	4
Question 35	23	8	2
Question 36	25	3	2
Question 37	37	0	0
Question 38	35	0	0

Agreements (N=40)					
	1	**2**	**3**	**4**	**5**
Question 39	7	11	4	3	1
Question 40	3	11	3	5	1
Question 41	1	14	3	4	2
Question 42	2	15	5	6	0
Question 43	6	10	4	3	0
Question 44	2	7	3	4	2

Agreements (N=40)		
	Yes	**No**
Question 46	14	19
Question 49	15	19
Question 52	11	20
Question 55	4	32
Question 58	12	22

Agreements (N=40)		
	Yes	**No**
Question 61	3	35
Question 62	6	31
Question 63	7	27
Question 64	3	32
Question 65	9	31

Agreements (N=40)				
	Daily	**Weekly**	**Monthly**	**N/A**
Question 47	6	5	1	18
Question 50	6	1	1	18
Question 53	1	1	0	20
Question 56	1	1	0	31
Question 59	4	1	3	21

Agreements (N=40)				
	Mild	**Moderate**	**Severe**	**N/A**
Question 48	5	3	1	18
Question 51	5	2	0	18
Question 54	3	2	0	20
Question 57	2	1	0	31
Question 60	4	4	0	21

Agreements: Q45 18/40								
6	**7**	**8**	**9**	**11**	**12**	**13**	**14**	**15**
1	3	1	4	4	1	4	1	1

APPENDIX E
ATTACHMENT 3

Job Requirements and Physical Demands Survey

Raw Statistical Data

							high=3	*sn=shoulder/neck*				*high=5*		*high=3*									
							med=2	*hwa=hand/wrist/arms*				*medhigh=4*		*med=2*									
							low=1	*bt=back/torso*				*med=3*		*low=1*									
								lf=legs/feet				*Medlow=2*											
								he=head/eyes				*Low=1*		*A.1*	*A.2*	*A.3*	*A.4*	*A.5*	*D.1*				
							ergo=ergonomist ratings							*rf=riskfactor ratings*						*dis=disco*			
WPI	**Base**	**Organ**	**Workplace**	**Bldg**	**Room**	**AFSC**	**ergosn**	**ergohwa**	**ergobt**	**ergolf**	**ergohe**	**ergorisk**	**ergorank**	**rfsn**	**rfhwa**	**rfbt**	**rflf**	**rfhe**	**dissn**				
201A	PAFB	301RQS	Structural Maintenance	313	NA	2A7X5	3	3	3	2	1	5	1	3	3	3	3	1	2				
518A	PAFB	DECA/MSC	Commissary-Meet Cutting Room	1365	Meat Cut	7047 WL7	3	3	3	2	1	5	2	3	2	3	1	1	2				
518A	PAFB	DECA/SO/PAT	Commissary	-	NA	GS2091-03	3	3	2	2	1	5	3	2	2	3	1	2	3				
	PAFB	45 DS/SGD	Dental Lab	1371	NA	NA	3	3	3	1	2	5	4	3	2	2	1	2	3				
	PAFB	45 SVS/SVRL	Library	-	NA	GS-1411-5	2	3	3	2	2	5	5	3	1	2	1	1	2				
	PAFB	45 MDG	Dental Treatment	1371	NA	NA	3	3	3	1	2	5	6	2	2	1	2	1	2				
	PAFB	45 CES/CEH	Housing Office	1061	NA	1173	3	2	3	1	2	5	7	2	1	1	1	1	1				
	PAFB	45 TRNS/LGTTF	Air Terminal	800	NA	2T2X1	3	3	3	1	2	5	8	1	1	2	2	1	1				
302A	PAFB	301 RQS/MAF	Hydraulics	-	NA	2A6X5	3	2	3	1	2	5	9	2	1	2	1	1	1				
	PAFB	45 MDG/SGOP	Medical Records	1381	1079	4A0X1	2	3	3	1	2	5	10	3	3	3	3	3	2				
	PAFB	45 SW/SESE	Systems Safety	423	S329	3A0X1	3	3	2	1	2	5	11	2	2	2	1	2	2				
	PAFB	45 SW/XP	Wing Plans	423	S229	301-13/801-13/318	2	2	3	1	1	4	12	1	1	1	1	1	2				
209A	PAFB	741 MS/MAES	Survival Equiment	750	NA	2A5X3	3	2	3	1	1	4	13	2	2	2	3	1	2				
122A	PAFB	45 CES/CEOHH	Horizontal Construction	912	Front Off.	3E2X1	2	2	3	1	1	4	14	2	3	3	3	1	1				
	PAFB	RAYTHEON	Shipping and Receiving	310	64770		2	2	3	1	1	4	15	1	1	2	2	1	2				
	PAFB	DECA	Commissary Whse.	NA	Comm.	NA	2	2	3	1	1	4	16	2	2	3	3	1	2				
	PAFB	45 TRNS/LGTTS	packing & Crating	310	Sur.Frght	2T0X1	2	3	2	1	1	4	18	2	2	3	3	1	2				
	PAFB	45 MDG/SGOPA	Appointment Desk	1173	NA	GS3035	2	2	2	1	1	4	20	1	2	1	2	2	2				
122A	PAFB	45 CES/CEOHVI	Vertical Construction	NA	NA	3E371	2	2	2	1	1	3	21	3	3	3	3	1	1				
115A	PAFB	45 CES/CEOIUF	Liquid Fuels Maintenance	610	NA	3E4X2	2	2	2	1	1	3	22	1	1	1	1	1	1				
126A	PAFB	45 CES Zone 2	Facility Maint. Zone 2	523	NA	4749	2	2	2	1	1	3	24	2	1	2	2	1	2				
115A	PAFB	45 CS/SCMMG	Radio Maintenance Work Center	957	NA	2E 173	2	1	2	1	1	1	25	1	1	2	1	1	1				
211A	PAFB	741 MS/MACA	Aerospace Ground Equipment	691	NA	2A6X2	1	1	1	2	2	1	26	1	2	3	3	1	2				
205A	PAFB	41 RQS/DOTL	Life Support	750	NA	1T1X1	2	1	1	1	1	1	27	2	1	2	2	1	1				
559A	PAFB	45 CS/SCM	Cable/Telephone Maint.	533	130	2E6X3	1	1	2	1	1	1	28	1	1	1	1	1	1				
518A	PAFB	DPS/DBO	Reproduction Shop	318	NA	GS11-1654	1	1	1	1	1	1	31	2	1	2	2	1	1				
DOA	CCAS	6 SWS	Administrative Assistant	2	Com. Sect.	3A0X1/13S3E	2	2	3	1	1	4	17	1	1	1	1	1	2				
CCQ	CCAS	6 SWS	Administrative Assistant	2	Orderly	3A71	2	2	3	1	1	4	19	1	1	1	3	3	1				
DOO	CCAS	6 SWS	MWOC	2	MWOC	1C651/13S1E	2	1	2	1	2	3	23	2	1	1	1	3	2				
SCC	CCAS	6 SWS	Security Controller	1	Sec. Contr.	3P051	1	1	2	1	1	1	29	1	1	1	1	1	1				
SP	CCAS	6 SWS	Entry Controller	10	Entry Contr.	3P031	1	1	2	1	1	1	30	1	1	1	1	1	1				

				D.2	*D.3*	*D.4*	*D.5*						
				omfort ratings				*ps=priority score*					
WPI	**Base**	**Organ**	**Workplace**	**dishwa**	**disbt**	**dislf**	**dishe**	**pssn**	**pshwa**	**psbt**	**pslf**	**pshe**	**rfdsrank**
201A	PAFB	301RQS	Structural Maintenance	2	2	2	2	7	7	7	7	3	7
518A	PAFB	DECA/MSC	Commissary-Meet Cutting Room	2	2	2	1	7	5	7	3	1	7
518A	PAFB	DECA/SO/PAT	Commissary	3	3	3	3	8	8	9	6	8	9
	PAFB	45 DS/SGD	Dental Lab	3	3	1	1	9	8	8	1	2	9
	PAFB	45 SVS/SVRL	Library	2	2	3	3	7	3	5	6	6	7
	PAFB	45 MDG	Dental Treatment	1	2	1	1	5	2	3	2	1	5
	PAFB	45 CES/CEH	Housing Office	1	1	1	1	2	1	1	1	1	2
	PAFB	45 TRNS/LGTTF	Air Terminal	1	1	1	1	1	1	2	2	1	2
302A	PAFB	301 RQS/MAF	Hydraulics	1	1	1	1	2	1	2	1	1	2
	PAFB	45 MDG/SGOP	Medical Records	2	3	1	1	7	7	9	4	4	9
	PAFB	45 SW/SESE	Systems Safety	2	2	2	3	5	5	5	3	8	8
	PAFB	45 SW/XP	Wing Plans	1	1	1	2	3	1	1	1	3	3
209A	PAFB	741 MS/MAES	Survival Equiment	2	3	3	1	5	5	8	9	1	9
122A	PAFB	45 CES/CEOHH	Horizontal Construction	1	1	1	1	3	4	4	4	1	4
	PAFB	RAYTHEON	Shipping and Receiving	2	2	2	1	3	3	5	5	1	5
	PAFB	DECA	Commissary Whse.	3	2	3	1	5	8	7	9	1	9
	PAFB	45 TRNS/LGTTS	packing & Crating	2	3	2	1	5	5	9	7	1	9
	PAFB	45 MDG/SGOPA	Appointment Desk	1	2	2	2	3	4	3	7	7	7
122A	PAFB	45 CES/CEOHVI	Vertical Construction	1	1	1	1	4	4	4	4	1	4
115A	PAFB	45 CES/CEOIUF	Liquid Fuels Maintenance	1	2	2	1	1	1	3	3	1	3
126A	PAFB	45 CES Zone 2	Facility Maint. Zone 2	2	2	2	1	5	3	5	5	1	5
115A	PAFB	45 CS/SCMMG	Radio Maintenance Work Center	1	1	1	1	1	1	2	1	1	2
211A	PAFB	741 MS/MACA	Aerospace Ground Equipment	1	2	2	2	3	2	7	7	3	7
205A	PAFB	41 RQS/DOTL	Life Support	1	1	1	2	2	1	2	2	3	3
559A	PAFB	45 CS/SCM	Cable/Telephone Maint.	1	1	1	1	1	1	1	1	1	1
518A	PAFB	DPS/DBO	Reproduction Shop	1	2	2	1	2	1	5	5	1	5
DOA	CCAS	6 SWS	Administrative Assistant	2	2	1	2	3	3	3	1	3	3
CCQ	CCAS	6 SWS	Administrative Assistant	1	1	1	1	1	1	1	4	4	4
DOO	CCAS	6 SWS	MWOC	1	1	1	2	5	1	1	1	7	7
SCC	CCAS	6 SWS	Security Controller	1	2	1	2	1	1	3	1	3	3
SP	CCAS	6 SWS	Entry Controller	1	1	1	1	1	1	1	1	1	1

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